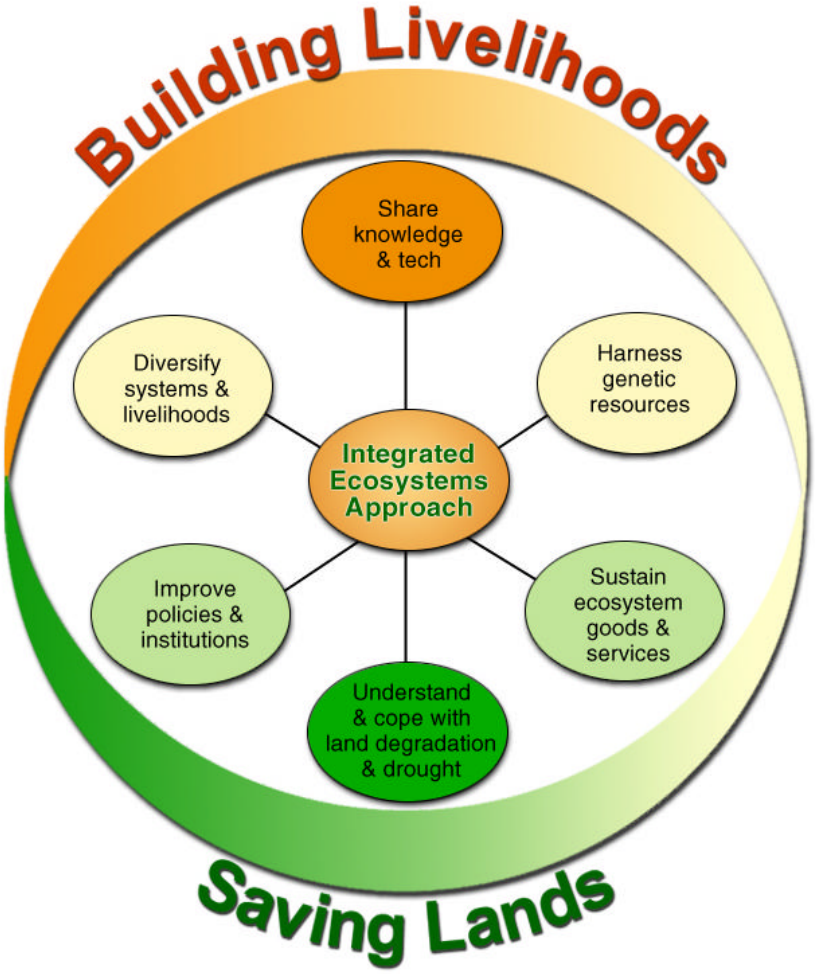
DESERTIFICATION, DROUGHT, POVERTY, AND AGRICULTURE



A Pre-Proposal for a CGIAR Challenge Programme

31 August 2002

Desertification, Drought, Poverty, and Agriculture

Building Livelihoods, Saving Lands

Defining the Problem

Desertification, drought, and poverty create a scenario of misery and insecurity across the drylands of Africa and Asia. According to the UN's Secretariat for the Convention to Combat Desertification (UNCCD), 250 million people have already been harmed by desertification, and another 750 million are at risk.

Desertification creates a downward spiral of lost productivity that has ramifications far beyond these areas, including refugee flights, social alienation and conflict, damage to global freshwater and marine resources, and atmospheric pollution. In a recent survey carried out by the International Council for Science (UNEP State of 2000 Report) on environmental issues that would require attention in the 21st century, desertification and deforestation ranked third out of 37 issues identified. Income lost due to desertification amounts to approximately US$42 billion globally.

The UNCCD defines desertification as "land degradation in arid, semi-arid and dry sub-humid areas resulting from various factors, including climatic variations and human activities". The most commonly cited forms of unsustainable land use are over-cultivation, overgrazing, deforestation, and ill-considered irrigation practices. Soils are being mined of nutrients at an alarming rate (Smaling, 1997; Van der Pol, 1992). Periodic droughts debilitate and destabilize poor societies, and contribute to land degradation by reducing vegetative cover and water supplies, triggering a desperate exploitation of the remaining resources in order to survive.

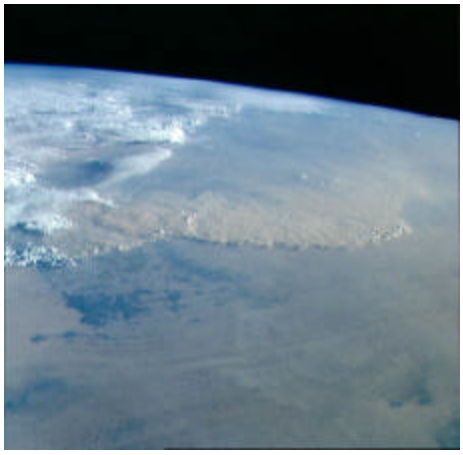
There are many factors that trigger desertification, including the unpredictable effects of drought, fragile soils and geological erosion, livestock pressures, nutrient mining, growing populations, inadequate/ambiguous property and tenure rights, landlessness and an inequitable distribution of assets, poor infrastructure and market access, neglect by policy makers and agricultural and environmental research systems, and the failure of markets to reward the supply of environmental services. Given this complexity of causal factors, an integrated approach including broad stakeholder participation is essential if peoples' livelihoods – and security needs – are to be improved.

An integrated view of ecosystems

Since the poor are simultaneously dependent on, yet vulnerable to events that change the quality of their land resources, approaches to improving their livelihoods must pay close attention to integrated ecosystem management. There is an increasing appreciation that agricultural components of the ecosystem are dependent on a large suite of *ecosystem goods and services* taken for granted too often in the past. If the true value of ecosystem goods and services were recognized, it is possible that society would make greater efforts to protect their ecosystems, including both natural and agriculturally-managed components. Worldwide, according

to the Smithsonian Institution and the US President's Committee of Advisors on Science and Technology (2001), ecosystems provide goods and services that would cost an astonishing US$33 trillion annually to replace, almost twice the value of all goods and services produced by people.

Goods and services from natural ecosystems that are crucial for the livelihoods of the rural poor include wild foods, timber, fuel, fiber, medicines, pollination services to crops, soil fertility regeneration, water storage and supply (drought and flood control), carbon storage, air and water purification, climate moderation, tourism potential, and cultural values, among others. Many of these also have global value, for example the carbon storage potential of the vast dry areas, and the role of ground cover in preventing massive dust storms that cross oceans.



Massive dust storms racing down the Sahel are visible from space – and cross the Atlantic

Linkages between poverty and environmental degradation

Do losses of these services cause poverty, or vice-versa? Causal relationships between poverty and land degradation are complex and cannot be assumed (TAC, 2000; Peter Hazell and Jock Anderson, personal communications). Environmental degradation in desertification-prone areas is not just a matter of poverty since non-poor people degrade resources too. For example, large herders are just as likely to overgraze open rangelands as small herders, and loggers and large ranchers are important agents of deforestation as well as poor farmers and migrants. Yet, the *effects* of degradation and drought are particularly serious for the poor, because they are the most dependent on natural resources for their basic livelihoods, and they have the least means to avoid or cope with the consequences.

Are poverty and degradation inevitable in desertification-prone areas?

Clearly, the livelihoods of the poor in desertification-prone areas are closely tied to the fate of their land. Many suggest that poverty and land degradation create a self-reinforcing downward spiral (Cleaver and Schreiber, 1994; Mink, 1993; Leonard, 1989; Durning, 1989). However, Boserup (1965) argued that as population pressure grows and labor becomes less costly relative to land, a process of "induced innovation" occurs whereby communities invest in agricultural intensification and in improving their resource base.

The empirical evidence on these views is mixed (see Pender 1999, for a recent review). A much-cited study of Machakos district in the Kenyan highlands with the provocative title "More People, Less Erosion" (Tiffen et al. 1994) provided a striking example of the induced innovation model and raised hopes within the development community. And there is increasing evidence of communities and households successfully managing degradation pressures and risks, given a favorable policy and institutional environment (Templeton and Scherr, 1999; Leach and Mearns, 1996; Tiffen et al., 1994). However, in many cases successful adaptations do not occur (Lopez, 1998; Kates and Haarmann, 1992).

Poverty and degradation in desertification-prone areas, it appears are not an inescapable destiny, although they are a grave risk. Either degenerative or

regenerative development outcomes are possible, depending largely on how people manage the desertification-related hazards and circumstances they face. These include success or failure to adequately adapt to rapid population growth, globalization, market development, technological change, climate change, and agro-ecological factors (Anderson, 1999; Heath and Binswanger, 1996; Jodha, 1998; Lele and Stone, 1989; Lopez, 1998; Mazzucato and Niemeijer, 2002; Niemeijer and Mazzucato, 2002; Prakash, 1997; Scherr, 2000). Common threads in the escape from poverty appear to be access to technologies that can increase land and labor productivity faster than population growth (Pender, 1998) along with access to markets (Pender, Scherr, and Durón 2001).

The Core Research Question, and Approach

The Desertification, Drought, Poverty and Agriculture Challenge Program (DDPA) is committed to help countries and regions gain the knowledge base they need to escape, and even reverse the downward spiral of desertification, drought and poverty. However, for those desperate to survive from one day to the next, practical and innovative alternatives to the mining and exploitation of scarce natural resources are not simple or obvious. They require in-depth research, linked to and in support of participatory development activities in the affected zones.

The core question that lies at the heart of prospects for successful and lasting interventions to combat desertification and drought, is: **how can poverty in resource-poor, desertification-prone areas be reduced and the poor achieve stable, secure livelihoods, without undermining the ecosystem goods and services that they vitally depend on?**

Integrated Ecosystem Approach

The breadth of issues linked to this question compels a holistic, integrative approach. Many past attempts at dryland development have failed because they were narrowly targeted to a particular component problem, or viewed agricultural production systems in isolation from the many ecosystem factors that confront real farmers in these areas (see in-depth discussion of lessons from the past in Appendix III).

This is why an integrated ecosystem (IE) approach is proposed by the DDPA. Table 1 (evolved from the concepts of White et. al. 2002) illustrates some ways in which the IE approach is distinguishable from narrower agricultural R&D approaches.

By way of clarification: both the IE and the integrated natural resource management (INRM) approaches are holistic and integrative; but the IE perspective includes entire ecosystem (natural as well as agricultural components, social as well as biophysical, and across all pertinent levels of scale), whereas INRM restricts itself to the agricultural domain and its relevant levels of scale, and the subset of stakeholders that are involved in that domain.

The outputs of the IE approach are not prescriptive recipes of fixed technologies. They are tools, models and processes that can be 'mass customized', i.e. adapted to a wide range of local needs and circumstances. Examples include suites of options for community consideration for sustainable watershed development; models to link participatory, conventional, and biotechnological plant breeding methods; and sets of principles that govern tradeoffs in policy decisions. Such *development process*

models are discussed further in the section on 'Mechanisms for Delivery and Dissemination of Outputs'.

Table 1. Conventional versus the integrated ecosystem (IE) approach

Aspect	Conventional Approach	Integrated Ecosystem Approach
Perspective	Natural ecosystems seen as input suppliers (land, fertility etc.) for current or future commodity production	Natural and managed ecosystems viewed as part of one interdependent whole, providing a wide range of goods and services
Products	A few commodities or products	A wide array of both managed and natural goods and services
Strategy	Maximize yield, production, and net present value by intensifying the use of land, labor, and capital	Optimize total ecosystem goods and services output over time
Methodology	Reductionist: high-resolution measurement of a small number of factors	System-oriented, including both quantitative and qualitative assessments with close attention to interactions, flows, asset balances, tradeoffs
Approach to diversity	Reduce diversity for more predictable results, more targeted interventions, and greater economies of scale	Take advantage of diversity to exploit niche potential, meet a wider range of needs, preserve future options, and reduce total system risk
Scales of work	Political and ownership boundaries	Ecosystem and landscape, societal plus biophysical
Role of science	Applied science focused on biophysical resources, geared towards specific technology outputs	Combine biophysical with social analysis, include policy and social context, create prototypes and models of development processes for local adaptation

The Six Research Themes

Applying the integrated ecosystems approach, six closely-interrelated research Themes will address different facets of the DDPA core question (summarized in the graphic on the cover page of this pre-proposal):

1. Understanding and Coping with Land Degradation and Drought Risk
2. Integrated Ecosystem Approach for the Sustainable Provision of Agricultural and Ecological Goods and Services
3. Policy and Institutional Options for Combating Desertification and Drought
4. Harnessing Genetic Resources to Combat Drought and Desertification
5. Income-Increasing Agricultural Diversification to Improve Livelihoods and Foster more Sustainable Land Use
6. Breaking Technology and Knowledge Barriers: Increasing Impact with an "ICT for Development" Strategy

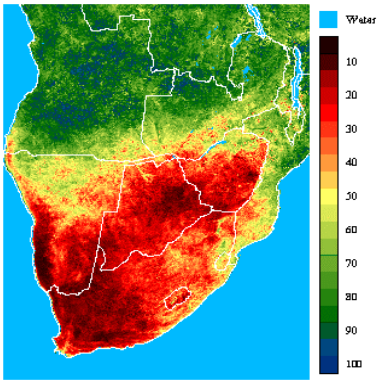
These Themes were developed through in-depth stakeholder discussions (including both a global internet discussion and a three-day workshop), drafted by co-leaders in each field, with one each from inside and outside the CGIAR. More details on this highly participatory process are given in the Consultative Process section.

A brief synopsis of each Theme is presented below. A full profile of each, including Purpose, Rationale, Hypotheses, Objectives, and Outputs, is in Appendix V. Initial partners are also specified; their comparative advantages are described in Appendix VI. Reference citations are consolidated for the entire document in Appendix VII. Acronyms and abbreviations are in Appendix VIII.

Theme 1 Understanding and Coping with Land Degradation and Drought Risk

The absence of practical and accurate methodologies for assessing and monitoring land degradation and rehabilitation has been a fundamental constraint to combating desertification so far. It has caused experts to differ widely in their estimates of the extent and causes of the problem, and to have difficulty measuring progress against it. Existing methodologies are either subjective or un-validated and are biased towards soil degradation (Scherr 1999; Scoones and Toolmin 1998; Mazzucato and Niemeijer 2000). Consequently, the studies that that are available are of low resolution, contain ambiguous and subjective information, are too costly to frequently repeat for essential monitoring of changes in degradation, and do not provide the level of detail that is needed for policy development and land management (see for example Oldeman et al. 1991; Stoorvogel and Smaling 1990; Wood et al. 2000; UNEP 1997).

The leading-edge approach we propose to develop in this Theme would develop analytical methods for direct measurements of ecological processes such as evapotranspiration from inexpensive, frequently-sampled satellite data (Rosema, 1993). These remote sensing analyses would be combined with on-the-ground participatory assessments of community perceptions and valuations of degradation and drought in 'consortium pilot areas' (described later) down to the catchment level of scale. Combined with an understanding of ocean-atmosphere interactions, these tools will significantly strengthen the capacities of communities, nations and regions to develop drought and desertification coping strategies through better and more timely information, including improved early predictions of impending drought risk (Palmer and Anderson 1994; Hastenrath 1995; Goddard et al 2001).



The advanced EWBMS technique developed by EARS, a DDPA partner, maps drought stress (red) in early 2002 relative to previous years in southern Africa based on direct physiological criteria (ET) especially relevant to agricultural production.

Expected outputs for impact include: rapid-assessment based hotspot detection methodology and tools to identify areas of likely degradation; pressure, state and impact indicators for the soil, water, biotic, and productivity components of land degradation and climatic variability; protocols and tools to measure and monitor actual land degradation in drylands integrating field and satellite data; participatory evaluation framework for the impact of land degradation and drought on dryland ecosystem functions; livelihood coping strategies using improved information on climatic variability; and training of local research partners and other stakeholders in generating, interpreting and using predictive and monitoring information on land degradation and climatic variability.

Initial core partners

EARS for remote sensing technology; Wageningen University for land degradation assessment participatory and monetary valuation, and environmental indicator development expertise; and IRI for drought prediction (see partner profiles in Appendix VI), partnering with GIS capacity at ICRISAT and ICARDA as well as national and regional partners.

Theme 2 Integrated Ecosystem Approach for the Sustainable Provision of Agricultural and Ecological Goods and Services

This Theme will build an understanding of the role and value of natural resources in both natural and agricultural components of ecosystems, especially in the provision of environmental goods and services. This understanding is vital for rational decisions to balance better livelihoods with healthy lands.

The non-equilibrium relationships between climatic and biotic variables in drylands mean that livelihoods in these areas have had to adapt to the constant risk of drought and desertification, either exploiting it through the mobility of pastoralism (Behnke et al., 1993) or mitigating it through the flexible pursuit of multiple livelihood strategies (Mortimore, 1998). The relationships of ecosystem degradation and recovery need to be better understood because the drylands are coming under increasing pressure from agricultural and other human activity. What is the tipping point beyond which degradation becomes effectively irreversible, what parameters trigger it, and how can it be averted? How can we help farmers and rural communities become aware when they are on the brink of losing their crops, livestock, and wild harvests – and know what to do about it?

Little is known, for example about the relationships between losses of ecosystem functions and their above and below-ground biodiversity, or of the requirements to initiate successional processes that will lead to the re-establishment of key functions that regulate and deliver valuable ecosystem goods and services. 'Keystone species' that are strategic intervention points for the health and survival of many other species in these ecosystems need to be identified and their dynamics understood. This knowledge is then applied as guidance for technical, policy, and institutional land management decisions.

Expected outputs for impact include: tradeoffs and win-win opportunities identified and understood for sustaining healthy ecosystem functions and resources (particularly biodiversity-related) in both managed and un-managed areas in the landscape; restoration dynamics understood and strategies developed and implemented; new and better integrated soil and water management strategies for soil surface management, water harvesting, integrated soil fertility management and cropping strategies; economic and non-monetary evaluations of outputs from managed and unmanaged land uses useful for policy as well as research planning; integrated ecosystem degradation monitoring tools and manuals developed and validated with land users (jointly with Theme 1); and training and knowledge-sharing resources developed (and shared through Theme 6) for key stakeholder intervention points and scale levels (community, government, region, international).

This Theme will bring together an innovative partnership of agricultural and ecological organizations, by including the Commission on Ecosystem Management of IUCN – The World Conservation Union. IUCN will advise and assist in the design and

implementation of assessments and monitoring of the natural components of landscape-level ecosystems, and in developing ecosystem restoration methods.

Initial core partners

ILRI, IUCN-The World Conservation Union, ACNU, Univ. of Hamburg (Desert*Net BIOTA project-southern Africa), UNEP, ICARDA, TSBF/CIAT, SWMNet, ICRISAT, and many additional partners.

Theme 3 Policy and Institutional Options for Combating Desertification

This Theme will assess policy and institutional factors that lead to unsustainable land use and assist countries in addressing them to foster more effective, balanced, environmentally-friendly management practices.

Much has already been learned about the underlying socioeconomic and policy *causes* of land degradation in dry areas. These include population pressure, poverty, lack of access to markets, inadequate or inappropriate, infrastructure, credit and other services, unclear land rights and land tenure insecurity, among others (Otsuka and Place, 2001; Platteau, 1996; Place and Hazell, 1993). Local institutions, such as community-based land use decision making capacities and social networks are also important in determining whether farmers are able to practice a non-degrading form of agriculture in drylands (Mazzucato and Niemeijer, 2002).

Much, however, still needs to be learned about how societies *respond* to desertification and drought. For example, it is not well understood under what conditions communal resource management institutions break down into unregulated open access conditions or evolve into effective institutions as population or market pressure increases. This understanding is essential for developing the policy and institutional advice that would help societies make the transition to more effective, culturally-appropriate mixes of private and socially-oriented systems.

The context-specific nature of impacts of policies and institutions are also not well understood (Pender, Place and Ehui, 1999). Lessons learned from research often tend to be site specific and not replicable to other regions. The difficulty of scaling up to national development strategies and/or scaling out to other communities will be important aspects of this Theme. The trade-offs and synergies among agricultural productivity, human welfare and environmental sustainability due to policy and institutional interventions are another priority issue.

Expected outputs for impact include: lessons learned from past studies and gaps identified; a GIS database classifying target pilot areas into development domains to identify entry points for launching sustainable economic development; options for pilot areas based on predictions of impacts and trade-offs of alternative policy and institutional options; consultations with policy makers and other stakeholders at local, national and international levels to share policy options and implementation guidelines; and trained research partners, stakeholders, local and national policy makers in use of policy tools and databases; documentation of the returns from using scarce public funds to invest in desertification activities.

Stakeholders in consortium pilot areas, national and regional experts within the UNCCD framework, and partner research institutions provide invaluable sources of knowledge that can be tapped to get to the heart of these issues through this

Theme. The UNCCD focal point partners also provide a pathway for engaging national and regional policy frameworks and decision-makers in a re-examination of policies and institutional arrangements so that Theme results lead to impact.

Initial core partners

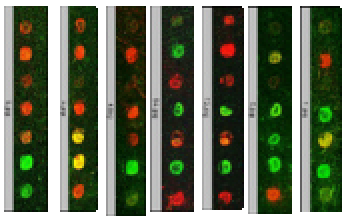
IFPRI, ICARDA, and the University of Marburg-Germany (through Desert*Net) along with DRFN focusing on southern Africa.

Theme 4 Harnessing Genetic Resources to Combat Drought and Desertification

This Theme will deliver a unique integration of participatory, conventional, and biotechnological plant breeding methods to attempt major new advances in improving and disseminating drought and salt tolerance in major dryland food and forage crops. Conventional plant breeding and crop physiology have had limited success in achieving these tolerances because of the complexity of the trait-environment interaction, and the variability of these stresses over time and space. But recent scientific advances hold new promise.

Scientists are finding that the genetic maps of different species within broad groupings (such as grasses) are surprisingly similar, a phenomenon known as *gene synteny*. Comparative genetics tools in grasses (Devos and Gale, 2000), for example now make it possible to apply the collective genetic information from *all* of the species in these groups, to improve any *particular* species within that group—once a small set of basic genetic tools for that particular species is available. These basic tools are already available, or are well along in the research pipeline, for the crops and forages in the research mandates of ICARDA and ICRISAT.

Our world-renowned partner TIGR (The Institute for Genomic Research) has the technological base and facilities to characterize homologous genetic markers for these crops and forages. ICARDA is contracting with TIGR to develop a generic oligonucleotide-based microarray that can be adapted to allow allele-specific, high-throughput genotyping of any organism at marker loci associated with, or genes controlling, any heritable trait. These *stress microarrays* will have an expected operational cost of around US$10 per test (approximately 90% less than the commercial cost in the USA). Use of this innovative technology for developing countries will reside in the public domain. This biotechnological approach does not use transgenic methods, which are controversial and could delay or impede the dissemination of research products for impact.



Microarrays reveal stress tolerant associations

Microarray tests can be affordably run on large numbers of varieties used locally by farmers (e.g., indigenous land races), and this information can be matched against farmer's knowledge and participatory measurements of drought and salt tolerance in their fields, to create an association of marker loci with preferred traits. The favourable genes identified can be quickly pyramided through conventional breeding techniques, and superior recombinants selected for another round of farmer testing. As farmers participate, they become familiar with the germplasm that suits their needs best, and need not later be dependent on formal multiplication and delivery systems for their seed – a widespread constraint in these areas.

Expected outputs for impact include: Haplotype databases; drought and salinity stress microarrays; crop genome databases linked to genetic resources databases and stress phenotyping databases; information on genes, QTLs, and linkage maps; alternative stress tolerance pathways described; sources of salinity stress tolerance and drought stress tolerance identified and characterized that differ in their genetic-mechanistic-physiological bases in target crop; improved breeding populations having locally preferred traits for salt and/or drought tolerance; comparisons of efficiency of component approaches and integrated approaches; experimental and released cultivars; germplasm and seed exchange; and feedback to integrated breeding programs from participatory trials via biotechnological tools.

Initial core partners

ICARDA, ICRISAT, CAZS (participatory methodology), TIGR (oligonucleotide microarrays), CERAAS (drought-West Africa), ICBA (salinity), ICGEB (salinity tolerance genetics).

Theme 5 Income-Increasing Agricultural Diversification to Improve Livelihoods and Foster more Sustainable Land Use

The DDPA's twin goals of building livelihoods (especially reducing poverty) while saving lands are closely interdependent, because farmers will only invest in land restoration when they perceive that by doing so their livelihoods improve in some way, especially through greater and more stable incomes (Sanders, Shapiro, and Ramaswamy, 1996). Therefore a search for diversified and higher-value agricultural and other land-use options is an important line of investigation for poverty reduction in marginal areas (Kerr et al., 2001; Sanchez et al., 2001; TAC, 2000).

Diversification of land use options can also contribute to ecosystem sustainability and restoration. It creates ground cover for soil protection, soil fertility (including organic matter and micro-organism diversity), microclimate, habitat, and other benefits. As new species are introduced, such as trees for example, they create new niches that are colonized by additional unplanned biodiversity.

Diversification research to date has mainly focused on higher-rainfall agro-ecosystems in the humid zones, both in Asia and Africa. There has been an assumption that the potential for diversification is less in the dry areas, but this has not been carefully tested. The natural biodiversity assets of dry areas are greater than most realize (see Appendix V, Theme 5). With appropriate land resource management, many high-value crops with export potential can thrive in dry environments. The relative lack of past attention to diversification in the drylands creates the possibility of rapid gains and high returns from research investment in this Theme.

Indigenous fruits like African Plum (*Dacryodes edulis*) can be exploited for higher market value

Gains in human capital through encouraging more diverse use of ecosystems are also of great significance. Through participatory knowledge-sharing and experimentation, farmers become central players in the domestication of high-value wild species (eg. Baobab, Moringa, *Ziziphus*, *Acacia*, *Marula*, *Warburgia*, *Sclerocarya*); the development of integrated agricultural and natural ecosystem

management capacities; and the startup of small enterprises to provide supplies, services, and output marketing of new products, all stimulating indigenous economic growth and self-reliance. As farmers and communities perceive enhanced value from their lands, they will become motivated to protect them for the longer term.

Promising avenues for exploration include the integration of higher-value crops, trees, and livestock into more diverse and complex, multi-storied 'garden' ecosystems yielding a more diverse and reliable stream of products over the annual cycle. Rangeland diversification will also be explored (eg. ICARDA and partner's success with thornless cactus in WANA). Ways to increase incomes through smallholder enterprises allied to these infrastructural and value-addition services will be sought, minimizing dependencies on costly imported inputs, services and marketing agencies. Economic analysis and consideration of policy incentives will be vital to success, jointly with Theme 3.

Expected outputs for impact include: development process models fostering participatory development of agricultural livelihood diversification; prototype farming systems that are more diverse, stable and productive than prevailing cereal-based systems; new or enhanced, higher-value agricultural products identified and integrated into existing systems; new input-supply, services and marketing system prototypes and models; new prototype agro-enterprises for income-generation; and knowledge/technology sharing to similar initiatives elsewhere.

Initial core partners

ICRAF, ICRISAT, ICARDA, ACNU, IFPRI, IPALAC, and DFRN

Theme 6 Breaking Technology and Knowledge Barriers: Increasing Impact with an 'ICT for Development' Strategy

An integrated ecosystem approach to building livelihoods and saving lands as needed for combating desertification and drought must be a knowledge-intensive venture. Local participation in understanding the problems related to desertification and drought and in devising solutions is essential for impact (see lessons of the past in Appendix III). The peoples living in desertification-prone areas hold local technology and knowledge (TK) resources that are critical in the search for solutions. Traditional TK interacting with contemporary TK can help partners think 'outside the box' to come up with new practices that are appropriate to their conditions. But finding practical means for engaging such intensive, ongoing dialogue across time, distance, and cultural gaps remains a challenge.

Institutional stakeholder groups such as governments, NGOs, private-sector, national, regional, international, and academic groups have their own cultures and norms – and restraints to TK-sharing. These constraints significantly impede sustainable development. Communities must be able to exchange views with governments, and agriculturalists must listen to and learn from ecologists, for example – particularly in the course of a participatory, holistic initiative like this one.

Technical factors are only one part of the challenge, of course but revolutionary new approaches are now possible that could create breakthroughs in this area. The rural telecenter strategy has shown great promise when appropriately implemented (PANTLEG 1999; UNDP 1999), providing a knowledge exchange platform that can benefit the poorest in villages that are remote and lacking basic infrastructure such

as telephone land lines and electricity – and connect them to the world beyond. The approach has garnered praise from the international press (Dugger 2000a and 2000b; The Economist, 2001; Reich, 2000). Drought early-warnings, ecosystem management practices, crop management advice, product price trends, natural resource management training modules, farmer and community feedback to national and international bodies, and farmer-breeder interchanges of results, are just a few of the possibilities that now appear within reach.

This does not mean that farmers must become computer literate. Skilled facilitators and community coordinators serve as community intermediaries in the telecenter hub-and-spoke model. They can also serve as liasons and facilitators of the Stakeholder Dialogue process at consortium pilot areas (see later section on Consultative Process). One source of such skilled personnel can be an innovative partnership with the United Nations Information Technology Service (UNITeS), a global e-volunteer mechanism launched recently by UN General Secretary Koffi Annan help bridge the 'digital divide' (www.unites.org).

Expected outputs for impact include: design and implementation of a Stakeholder Dialogue process to ensure for participatory evolution of the DDPA's agenda, and to ensure continuing understanding and ownership of its priorities, processes and outcomes; user-friendly internet systems and associated processes for integrating global, regional, national, and community TK resources related to the Program's domain of work; knowledge flow maps and knowledge network analyses identifying and providing an understanding of flows and blockages among key partners and stakeholders, and devise & test means of easing them; and rural telecenter models developed and piloted based on community ownership and participation.

Initial core partners

ICRISAT (telecenter pilot expertise), IDRC (global telecenter assessments and insights), UNV (community e-volunteers as TK intermediators), DRFN (community participation and TK exchange expertise)

What is New in the DDPA Approach?

A review of the DDPA Themes reveals that the DDPA approach differs in important, fundamental ways to address the limitations of past attempts (see Appendix III) to combat desertification:

An integrated ecosystems approach: most past efforts were narrowly focused on single or just a few technologies, failing to take into account (and capitalize on) the complex interactions among social, technical, environmental, political, financial, cultural, and other dimensions.

Attention to environmental services: ignored too often in the past, this Program will investigate the sustainable provision and valuation of services that healthy ecosystems provide to the rural poor and other sectors of society.

Pursuit of diversified livelihood opportunities: most agricultural R&D initiatives in the past attempted to improve a small number well-established agricultural patterns and livelihood occupations. The DDPA will attempt to "look outside the box", including participatory domestication of indigenous species, much more biodiverse agricultural systems, and new small enterprises.

Addressing inputs and markets: past approaches usually assumed that key inputs and markets would take care of themselves. DDPA recognizes the fundamental importance of research on innovative ways to "close the loop" to inputs and markets.

Attention to policy and institutional dimensions: past innovations, even when promising, often failed to be implemented because they were created in isolation from the policy environment needed to motivate their adoption. The DDPA will place a major emphasis on policy and institutional constraints and their resolution.

Participatory involvement at all levels: past efforts usually created solutions with minimal participation of intended users, resulting in uptake failures. Participatory methods will be applied in all six Themes.

Partnership-based: historically, most institutions primarily relied on their own areas of competence, resulting in narrow disciplinary or sectoral solutions. The DDPA will be broadly partnership-based, beginning with its close alliance with the UNCCD and GM mechanisms.

Close partnership between agriculturalists and ecologists: this Program is forging innovative partnerships between agricultural institutions and environmental organizations such as IUCN – The World Conservation Union, and UNEP.

Leading-edge science: The pace of global scientific innovation has accelerated substantially in recent years, particularly in genomics/biotechnology, information technology, modeling, and satellite remote sensing, and the DDPA will capitalize on these new opportunities.

Scale: most past efforts have been specific to locations and with limited attention to the costs and practicality of widespread deployment and adoption. The DDPA design has chosen its approaches with careful consideration of the scalability of likely outcomes, which should result in more effective adoption.

Mechanisms for Delivery and Dissemination of Outputs

Spotlight on participation

A broad spectrum of partnerships has been established within the DDPA. One reason for this is to create understanding and buy-in by involving partners from the start. As Program outputs take final form, partners will already have a confident understanding of their nature, applicability, need for local customization, and other features pertinent to achieving adoption and impact.

Experiences in participatory plant breeding illustrate this phenomenon – farmers, convinced by their involvement during the testing stages, usually adopt quickly and on a large scale, and multiply seed themselves, resulting in a shorter time frame to impact than the traditional stepwise development, testing, demonstration, and seed multiplication chain of events (Rohrbach et al., 1997; Tripp, 1997; Witcombe et al., 1998). A similar gain in speed and scale of adoption is expected for most outputs of the DDPA.

Development process models

As mentioned earlier, the outputs of the DDPA will largely be '*development process models'* – combinations of prototype tools, methods and processes that have a high likelihood of leading towards desired outcomes when conscientiously applied in different settings. Development process models are advantageous because they are

malleable and adaptable, so they can be customized to a wide range of circumstances. Their differing implementations in different locations tend to promote diversity, which is an important risk safeguard in desertification-prone areas. Thirdly, they carry the built-in characteristic of client participation in the customization process, which enhances buy-in, adoption, and continued evolution of the output through client experimentation. Successful examples of the implementation of development process models are described in Appendix III.

Engaging policy and decision-makers

As explained earlier, many if not most outputs will necessarily involve actions at more than one level of scale, including for example the national policy level (e.g. in the example of participatory breeding, national seed policies might have to be modified). To facilitate this, the DDPA will continue to cultivate its strong relationship with the UNCCD framework, which links directly into national, sub-regional, regional, and international policy and decision-making authorities and institutions.

Consortium Pilot Areas

The integrated ecosystem approach requires in-depth study at carefully-chosen pilot areas. Approximately 8-10 such areas in Africa and Asia will be chosen, depending on the resources available. Each area will include at least twenty villages for comparative analysis and replication.

A consortium approach will engage the key local stakeholders (farmers, farmer organizations, NARES, NGOs, private sector), local and national policy makers, and national and international research partners in identifying, carrying out, and evaluating holistic solutions. Site working groups will be established from the stakeholder membership, as a mechanism for overseeing operations on the ground and ensuring continuous channels of communication.

The pilot areas will be chosen using the following criteria:

1. The area should have a high percentage of drylands with significant degradation problems (along with some comparison areas that are not degraded) and/or climatic variability, plus a mosaic of managed and un-managed land use/production systems.
2. There should be a gradient of population and income levels, and varying access to markets and edapho-climatic conditions.
3. Areas should be linked to existing work under the UNCCD's action plans.
4. An institutional presence and interdisciplinary activities related to desertification should already be present.
5. There should be active community participation.

Where possible the selection process will take advantage of existing areas that meet these criteria, such as those chosen and characterized already by the Desert Margins Program, ongoing related UNEP and IUCN activities, and the partnerships underway between CGIAR Centers and national and sub-regional partners.

Stakeholder Analysis and Partnerships

> "To be successful, the implementation of the Convention to Combat Desertification should be based on a good understanding of the negative impact of desertification and the role that natural resource assets play in determining the economic opportunities open to poor households."
>
> Ambassador Hama Arba Diallo, UNCCD Executive Secretary

Since its inception, the DDPA has been a close partner of the UNCCD and its Global Mechanism. As a result, the DDPA outputs are closely aligned with the UNCCD goals and objectives. The UNCCD partners are enthusiastically expecting major accomplishments from the DDPA. They have a framework for interaction to and from the national, sub-regional and regional levels, through the identification of national nodal points and the development of Action Plans (NAP, SRAP, and RAPs) and Thematic Programme Networks (TPNs) for combating desertification. All these mechanisms provide a powerful facility for delivering impact from DDPA research results. Several other UN partners are also playing a catalytic role, namely UNEP, UNDP, UNV (UN Volunteers) and FAO.

Within the UNCCD framework, the DDPA will have many active research partnerships with the NARS and regional organizations in Africa and Asia. To mention just a few, the ASARECA, CORAF/WECARD, and SACCAR relationships will be key, including participation with their institutional members specializing on desertification-related issues such as INSAH/CILSS, CERAAS, SWMNET, DRFN, and others; and with the Thematic Programme Network (TPN) for the Sahel on agroforestry, and on soil conservation led by INSAH.

The DDPA will also draw upon the strong experience of the Desert Margins Program (DMP) in Sub-Saharan Africa. Convened by ICRISAT, the DDPA will be a perfect complement to DMP, adding a world-class research dimension and a global scope to the DMP's more applied agenda focused on Africa. The planned integration of the DMP into the DDPA is discussed in Appendix IV.

In the WANA region the DDPA will build on the close links that have already been created through the Mashreq/Maghreb project, and have grown into a regional program under the UNCCD umbrella. The DDPA is already linking with development projects in Morocco, Tunisia, Jordan, Algeria, and Iraq funded by IFAD, AFESD, UNDP and FAO. For Central Asia and the Caucasus, the DDPA will pursue opportunities jointly with the UNCCD-GM which plans to soon locate a person in the ICARDA-PFU offices in Tashkent.

In South Asia, ICRISAT's close relationship with Indian National Program, specifically CAZRI and CRIDA (further details in Appendix VI), will tie in to the larger sub-region through the TPN for South Asia on agroforestry and soil conservation led by CAZRI. ICARDA and ICRISAT's collaboration with Pakistan will create a platform for partnership. In China, the DDPA has engaged with the Chinese Academy of Agricultural Sciences and the Soil and Fertilizer Institute - Center for Water Resource & Conservation Technologies (Beijing).

The DDPA has strongly committed to an integrated ecosystem approach, but agricultural institutions have limited expertise in natural ecosystem research. Partnering is the solution. Ecological assessments, advisory services, and the

participation of ecosystem approach specialists will be contributed by the IUCN Ecosystem Management Programme.

In addition to these cornerstone partnerships, the DDPA will draw upon a global pool of expertise from both the developed and developing world. Such partners include the non-profit organization The Institute for Genomic Research (TIGR), a world leader in genomics including an early pioneer in sequencing the human genome; and Environmental Analysis & Remote Sensing (EARS), a leading-edge spatial analysis firm in The Netherlands; and many others, described in Appendix VI. Underpinning these partnerships will be the involvement of six CGIAR Centers: ICRISAT and ICARDA (co-convenors) plus ILRI, ICRAF, IFPRI, and TSBF/CIAT. More may join in the near future. The relationship of the DDPA to sister Challenge Program candidates and other major projects is described in Appendix IV.

Consultative Process

The concept and ideas behind the DDPA were brainstormed through an internet discussion involving more than 100 experts from around the world. Over 300 thoughtful contributions were posted. Theme co-leaders, one each from inside and outside the CGIAR, drafted the initial ideas, posted them on the internet site, and went through two rounds of revision based on the internet input. The consultation was crystallized in an intensive workshop hosted by ICARDA in Aleppo, Syria during 4-6 August, sponsored by the UNCCD Global Mechanism, IFAD, ICRISAT and ICARDA. More than 40 experts including UNEP-GEF, UNDP, IDRC, NARS from regional and subregional networks across Africa and Asia, the IUCN, universities, six CGIAR Centers, and several advanced research institutions participated.

In the Aleppo Workshop, NARS gave their ideas on priorities for their regions, partnerships, and potential donors. Integrated across regions, this gave a picture of global as well as region-specific priorities. Policy and institutional constraints were widely mentioned. Water management and salinity were great concerns of the CWANA zone, whereas biodiversity loss and the need for technology and knowledge exchange were the most pressing concerns in Sub-Saharan Africa. International and advanced research institute partners also shared their advice on technical content, governance models, and funding strategies.

This consultation will be continued through a permanent *Stakeholder Dialogue* process. Frequent consultative meetings, workshops, seminars, team field visits, and publications will be prominent features. Innovative use of the internet will sustain the exchanges of ideas between physical meetings. The telecenter model (see Theme 6) will attempt to break new ground by enabling a live link all the way from the global to the community (consortium pilot area) levels. A DDPA website will provide an integrating hub for information resource access and exchange.

Management and Governance

The DDPA will be governed by a Steering Committee (SC) co-chaired by the Directors General of ICRISAT and ICARDA. ICRISAT and ICARDA provide the legal and management authority for the DDPA through the SC. An independent Science Advisory Committee (SAC) will advise the SC on research matters. The Chair of SAC,

an eminent scientist, will also be Vice-Chair of the SC. At the present time, the suggested membership (subject to further discussion) is as follows.

Steering Committee

Directors General of ICRISAT and ICARDA (co-chairs), plus the SAC Chair as SC Vice-Chair, plus six Theme leaders, an IUCN representative, four or five sub-regional representatives who are also research partners and represent the pilot areas, and the Program Manager as Secretary.

Science Advisory Committee

An eminent scientist (Chair) plus 2 development-investor representatives, one representative each from the UNCCD Global Mechanism, the UNCCD Committee on Science and Technology, UNEP, GFAR, and a CSO representative; plus 4-5 regional and/or sub-regional NARS representatives (number to be determined).

Program Manager

A full-time manager is proposed who will handle the operational management and execution of the Program including accountability for implementation of the decisions of the Oversight and Steering Committees. The program manager will also develop and maintain contacts with donors.

Consortium Pilot Area Working Groups

Working groups, preferably led by NARS scientists, will oversee operations in each consortium pilot area. They will also nominate the steering committee sub-regional representatives.

Resourcing the DDPA

Intended for consideration as a CGIAR Challenge Program, the DDPA is a major global undertaking catalyzing joint action by many partners to tackle one of the most pressing human and environmental problems of our time. To achieve its objectives, an estimated 10 million US dollars will be required annually to enable operations during the first five-year phase.

Several investors have already indicated strong interest in investment once the CGIAR determines its own commitment. Substantial interest has been expressed so far by IFAD (approximately $1.5 million over 3 years), and UNEP/GEF ($2 million) to participate in the Niger-Nigeria transboundary project. The UNCCD Global Mechanism and IFAD have already assisted by providing $35,000 to supplement ICARDA and ICRISAT's investments in the pre-proposal workshop, and will continue as close partners in the resource mobilization arena.

Other candidates for "champion" status as development investors include GEF, which is expected to add land degradation as a funding window in November, 2002; the Asian Development Bank (AsDB), which has expressed strong interest in desertification work in dryland Asia; the African Development Bank (AfDB), which has recently elevated the priority of combating land degradation including desertification based on its linkage to poverty reduction; the World Bank (WB), which also prioritizes combating land degradation, and is a core sponsor of the UNCCD mechanism as well as desertification-related activities within the CGIAR; the EU and USAID in view of recent heightened security concerns linked to poverty and

development in many dry areas; the OPEC Fund, and the Arab Fund (AFESD) in view of the dryland status of many of their member countries.

The DDPA will include both new activities, and the folding-in of some highly relevant and important existing projects. Notably among these are the Desert Margins Program (US$50 million over six years, including a new 15.5 million biodiversity increment; approximately $10 million of this is for research); the new USAID TARGET project on Fertilizer Micro-Dosing/Warrantage in Niger, Burkina Faso, and Mali (total US$ 500,000 over 2 years, mostly for dissemination activities); the Mashreq/Maghreb Project convened by ICARDA and IFPRI in WANA, funded by IFAD, AFESD, UNDP and FAO; and the proposed Regional Programme on Sustainable Development in the Rainfed Areas of WANA (Post-Rabat Ministerial Meeting held in June 2001, Rabat, Morocco), which has a good likelihood of funding at $5 million over five years (approximately 10% for research). Our ecology-sector partner IUCN has also expressed interest to combine efforts and resources in West Africa on the integrated ecosystems approach including assessments and capacity-building, as well as land restoration and other topics. The GEF-funded LUCID project coordinated by ILRI will also be brought under the umbrella of the DDPA. See more elaboration of these projects/programs in Appendix IV.

The resources associated with these existing programs/projects provide a strong foundation for launching the DDPA, but it is evident that the bulk of their investment is geared toward applied development activities. These provide crucial channels for impact, but must be complemented by research funds to the $10 million level if the innovations described for the DDPA are to make new advances possible in the struggle against desertification and drought.

Principles and protocols of resource allocation

The two convening CG centers will carry the overall legal authority, accountability, governance, and management responsibility for the DDPA. They will also be responsible to enter into funding contracts to carry out the DDPA's central and cross-cutting activities. Individual partners and/or groups of partners carrying out activities in pilot areas may enter into contracts as they carry out consortium pilot area activities, and sub-regional activities. All partners are expected to make significant in-kind contributions to DDPA activities as well.

Shared, cross-issue Challenge Program financial resources would be open to and allocated to partners and others external to the CP through a peer review process for research project approval.

Full proposal development plan

The plan for development of a full DDPA proposal is provided in Appendix II.

List of Appendices

Appendix I. Responses to advice from the Interim Science Council for revision of the December 12, 2001 pre-proposal

(iSC comments in italics; responses are non-italicized)

1. Quality of Science

Clear definition of research objectives:
The background and justification, which typically provide the rationale for the objectives, are not spelled out sufficiently. A clear exposition of the large body of previous work (and results) is missing, e.g., DMP's objectives, accomplishments and current undertakings are not referenced, although the DMP web-page shows excessive overlap with this CP.

The revised Rationale ('Defining the Problem') describes the enormity of the desertification and drought problems, their causes and relationships to poverty and ecosystem degradation, citing widely-respected authorities on key points. More detailed rationales accompany each of the six Themes, again in expanded versions in Appendix V, with extensive citations. The Desert Margins Program (DMP) is discussed in the Stakeholder and Partner Analysis section, the Resourcing section, and in the Appendix IV discussion of relationships to major programs/projects, including the road map for the integration of DMP into the DDPA-CP. This integration will capitalize on the DMP's strong base of experience and applied linkages in Africa, to which the DDPA will add a strong research capability and global reach.

The CP pre-proposal claims that previous initiatives--due to their strong technological orientation--have failed, but it is not clear or convincing from the pre-proposal that the proposed initiative would fare better. The core assumption that "technological solutions have been emphasised which ignore the immediate needs and livelihood strategies of the rural poor..." is just that--an assumption, and is not supported by any evidence in the pre-proposal. A second crucial assumption, also made without sufficient evidence, states that "even when there have been technical solutions that have met client perceived needs, bottlenecks for implementation often exist at the institutional and policy making levels." Statements such as these must be qualified and conditioned by specific circumstances. Are there any research studies and clear results to document this broad generalization? Finally, the pre-proposal states that "past efforts have tended to be piecemeal and scattered without adequate consideration of the need for up-scaling." Taken together, these three assumptions are the basis upon which the CP is designed. This CP will rise or fall on the validity of these three premises. More effort will need to be given to substantiating the premises on which this CP rests, or, in the design and testing of these hypotheses within the CP itself.

These issues are now extensively referenced and discussed in depth in a special six-page section in Appendix III. Leading authorities in different regions and disciplines have been consulted in this process. The discussion now has the broader perspective of not just what went wrong in the past, but what was learned from those experiences and how that learning can be applied in the future to improve chances of success. These lessons are then linked to the basic design principles of the DDPA such as the integrated ecosystem approach and development process models, and are elaborated in a 'What is New' section.

Six specific potential research objectives are also defined, but relevant details/background are not sufficient. The two-page appendix describes some of the indicative research activities, but fails to provide adequate information about key researchable issues and priority objectives. A number of hypotheses are also stated but since they do not appear to be tested, they are probably better referred to as underlying assumptions.

A core research question has now been defined and elaborated in the form of six Themes which in turn are elaborated in considerable detail including purpose, rationale, hypotheses, objectives, outputs, and core partners. The page limit constraint for the pre-proposal is handled by flowing much of this detail into Appendix V. but effort has been made to give a sense of the rationale, strategy and opportunities for impact within the page constraint of the pre-proposal document itself.

Appropriateness and scientific rigor of research methodology/approach:

Scientific methods and research methodologies are not defined explicitly, though one might argue they are implicit in the CP outputs. There are references to general methods, e.g., farm surveys, field experiments and simulation models but specifics are lacking.

The overarching methodology of an 'integrated ecosystems approach' is elaborated in detail both in text and in a Table. Participatory methodology is described extensively, and explained in some detail in the Theme 4 profile (Harnessing Genetic Resources). The Theme profiles are far more detailed than in the previous draft of the pre-proposal, expanding the bulk of the document substantially into the Appendices. The detail of specific experimental methodologies lies beyond the scope of a pre-proposal, but a number of key leading-edge techniques are mentioned in the relevant Theme profiles, such as remote sensing, evapotranspiration-based water balance models, oligonucleotide-based stress microarrays, and rural telecenters. The engagement of world-class experts as Theme core partners (statements of competence in Appendix VI) should also reassure readers that modern, rigorous, leading-edge experimental methodologies will be employed.

Four development-oriented outputs for the CP are defined: livelihood strategies, technologies, organizational and institutional innovations and policies. These are very general…There is need for more focus and the critically important outputs should be well-defined. Furthermore, the description of the partnership arrangements and research methodologies do not provide a basis for these output expectations.

Six Themes are now specified, with 5-15 outputs each listed in Appendix V, reaching a much greater level of detail. By their nature, many outputs in the field of natural resources management are in the form of development process models, principles, approaches, processes and prototypes, rather than finished technologies. As an integrative science, the outputs of integrated ecosystem research must be shaped and customized for application and interaction in different combinations in particular settings. The rationale and *modus operandi* for this is elaborated in a new section on 'Mechanisms for Delivery and Dissemination of Outputs'. Partnership arrangements are explained in much greater detail in numerous parts of the document, aided by the opportunity to have had prior discussions over the internet and to have met and discussed in person in Aleppo in early August. 'Core partners' heavily involved in

developing the concepts and approaches so far are listed in the text and in the Theme profiles in Appendix V (not to prejudice the DDPA's openness to adding more partners in the future).

Qualifications, competence, comparative advantages of CGIAR Centres and their partners: This issue has not been addressed, as the pre-proposal does not describe the confirmed partners or their roles. The envisaged research partner list seems to cover a vast array of potentially interested organizations and institutions and may be overly optimistic. It also includes several non-research partners (farmers, farmer organization, NGOs and CSOs)…it is not obvious that the CGIAR has a comparative advantage in building capacity for local, national and regional planning and development activities, so it is essential that this point is elaborated upon.

Highly respected institutions, represented by Theme co-convenors are now specified for each Theme, as explained above. They led the drafting of the Theme sections and have made their commitment to the DDPA explicit. Their niches, competencies and comparative advantages are elaborated in Appendix VI. Additional organizations contributed to the current draft, and more will be engaged if the pre-proposal moves on to the full proposal stage. Non-research partners are essential in engaging local communities in the participatory mode described as fundamental to the DDPA and in capacity-building, so that the research partners can focus on their areas of comparative advantage while maintaining a dynamic, participatory linkage to groups that can work with communities to translate these results into impacts on the ground. Linkages to local, national and regional levels of scale are explained (participatory methods, UNCCD framework linkages, enhanced knowledge flows across levels of scale, and the ripple effects of successful development process models.)

2. Relevance to CGIAR Goals and Impact

Generally, mechanisms for delivery of research outputs need to be clearer.

A new section on 'Mechanisms for Delivery and Dissemination of Outputs' has been added to explain how integrative and participatory research at a limited number of consortium pilot areas can identify 'development process models' that ramify quickly to deliver increasing impacts across large target domains. The tie-in to government decision-making structures through the UNCCD framework is also explained. Regional research networks such as CORAF, CILSS/INSAH, ASARECA, SACCAR, SWMnet, Mashreq/Magreb, and others have been engaged in the process and are enthusiastic partners. Partnership with NGOs and e-volunteers such as the UNITeS/UNV network is also presented to illustrate how technologies will be shared for impact.

Strongly international public goods-oriented: Seems evident, but not highlighted nor well argued in the pre-proposal. If major outputs are to be process development models to be tested for wide applicability (needs stronger emphasis if such is the case), then this clearly qualifies as an IPG.

The outputs of the six Themes will follow the generally accepted policy of the CGIAR Centres to ensure that they remain in the public domain. Germplasm products from Theme 4 will reside in the public domain, and do not employ transgenic methods or envision tie-ins to proprietary genes or processes that could restrict public access. Development process models, prototypes, system analyses and other tools can be

thought of as knowledge products that will be freely available and will have wide application. This is explained in the new section on 'Mechanisms for Delivery and Dissemination of Outputs'.

3. CGIAR Partnerships and Stakeholder Involvement

Stakeholders' involvement and participation in problem identification, research planning and implementation: The extent of stakeholders' involvement in the developing the CP pre-proposal is not clear, except for ICRISAT and ICARDA.

The consultative process is now explained in detail in a special section. The lead research partners and their competencies are described in Appendix VI.

Many potential partners are identified thus far, probably too many, and their planned roles are open. If all are fully committed partners, the transactions costs will be very high. It would appear that the list is a generic one and the potential partners are not aware of their involvement. Kinds of collaborative arrangements and partners' commitments are not specified in the pre-proposal.

The partners described in the Stakeholder Analysis and in Appendix VI have made significant contributions of time and effort so far, and have expressed genuine commitment going forward. Transaction costs are a real but unavoidable fact of partnership-based research. Partners are carefully selected and expected to contribute some in-kind effort, which tends to restrict the scope to only the most active and interested organizations.

The proposal envisages that multiple partners and inter-regional cooperation would bring added value in this programme but the mechanisms to ensure this are not spelled out. A key requirement is to pay more attention to the structure as proposed in the pre-proposal, as an optimum structure will be essential. A Working Group is proposed, led initially by ICRISAT and ICARDA, that would be responsible for all research, stakeholder dialogue and fund raising. This should be re-considered as it may be advisable (to enlist genuine ownership) to move more quickly to establish a broadly based Steering Committee to coordinate all activities.

The initial decision of ICARDA and ICRISAT to partner as co-convenors fuses the key relationships and networks they participate in for both the tropical and temperate drylands all across Africa and Asia. The relationship to sub regional, regional, and national networks, partnerships and institutions is now described, along with the umbrella partnership with the UNCCD framework. Greater specificity is provided concerning the governance model, with the apex body (Steering Committee) including broad stakeholder membership.

The description of capacity strengthening as integrated into the research is not specified.

The central role of stakeholder participation is now explained throughout the document. This active participation of stakeholders in development will complement specific training activities in the respective Themes. Theme 6 focuses almost entirely on mechanisms for increasing the sharing of knowledge and technology which directly targets capacity-building.

There is clearly donor interest in the DMP and USUS$16 million is expected from GEF, but what is not clear is whether this will be embedded in the CP? Are the DMP resources included in this programme? The Asian Development Bank and IFAD have expressed interest in this topic.

Appendix IV on "Relationship to Sister Challenge Programs and Other Ongoing Programs/Projects" now explains how the new GEF-DMP project will be folded into the DDPA and how the DDPA will incorporate and supersede the Systemwide Ecoregional Desert Margins Program. It also explains that while the very substantial resources of the DMP and other fold-in projects will provide a superb and essential channel for the DDPA to achieve participation, dissemination and impact, they are mostly of a development nature rather than a research nature, so the research targets of the DDPA will need to find additional resources in order to reach their objectives. The section on 'Resourcing the DDPA' provides additional details of tentative donor interest that can be explored with good likelihood of success once investors see that the CGIAR itself has made a firm commitment to this Challenge Program, and that it has the critical mass of partners and relationships such as the DDPA, Mashreq/Maghreb, IUCN, and others that have been forged during the pre-proposal process. Initial support from GM and IFAD is acknowledged and further indications from IFAD and GEF are mentioned, and other likely investors are mentioned.

Appendix II. Plan for the development of a full DDPA proposal

The pre-proposal process has made a very good start already in establishing close partnerships (including with the UNCCD framework) and agreement on the DDPA's focus and strategies. This provides a solid basis for efficient progress into the full proposal stage. The events and timeline envisaged are:

1. A DDPA Steering Committee will be established and will meet to guide the program and will develop and refine issues of management and governance, advancing the Stakeholder Dialogue, site selection criteria, the strategy for funding, links with other Challenge Programs, and other startup tasks (by March 15, 2003).
2. A website will be developed integrating information resources (from October 2002 onwards) and internet discussions already begun during the pre-proposal phase will be continued to carry forward the momentum of the Stakeholder Dialogue process.
3. Consultants will be recruited to assist in for regional Consultation Meetings as part of the Stakeholder Dialogue (by March 15, 2003).
4. Proposal Consultation Meetings for the four regions (SSA, South and SE Asia, North Africa, and West/Central Asia and the Caucasus) will be held (March 15 – April 15, 2003).
5. A technical workshop will be held on to assess remaining knowledge gaps on desertification, drought and poverty (by end April, 2003).
6. Proposal drafting (April 15 - May 1, 2003).
7. Stakeholder feedback on draft (May 1 - 15).
8. Final proposal writing (May 15 – June 1).
9. DDPA Steering Committee meets to approve proposal (early June, 2003).
10. Proposal submittal (June 15, 2003).

Budget

A sum of US $200,000 is needed to enable the above activities culminating in the submission of a full proposal including a business plan:

Consultant support to the process	US$ 40,000
International travel, accommodation and subsistence of organizers	US$ 20,000
Consultation meetings with Stakeholders (including travel, accommodation, subsistence, interpretation, supplies, etc for 5 day meeting)	US$ 80,000
Technical workshop	US$ 30,000
DDPA Steering Committee Meetings	US$ 20,000
Secretariat assistance (translation, communication, etc.)	US$ 10,000
Total	**US$ 200,000**

Appendix III. Learning from past lessons

In Africa desertification has been on the agenda as early as the 1930s as colonial authorities and scientists, amongst others, inspired by the North America 'Dust Bowl' experience, became concerned about "harmful" African agricultural practices (Anderson 1984; Swift 1996). This formed the basis of the first generation of interventions, which was characterized by coercive regulations and large scale top-down protection schemes organized by colonial authorities.

A second generation of interventions followed after independence, mainly in response to strong population growth and the droughts of the early 1970s and mid 1980s. Again, large-scale and mainly top-down, these interventions were hardly a success, ill-supported by the local population and with structures typically breaking down immediately following project termination (Marchal 1986; Scoones et al. 1996). Ignoring and underestimating local knowledge appeared to be a major reason for limited impact (Chambers et. al 1989, Mazzucato et. al. 2001).

The apparent failures led, in the late 1980s and 1990s, to a third generation of interventions that attempted to take into account indigenous knowledge and followed a more participatory approach to development (Biot et al. 1995). However, stories of success remained few and doubts arose as to whether the participatory, project-based approach would be able to deal with the land degradation problems fast enough (Mazzucato and Niemeijer 2000).

While the third generation continues to be integrated further into mainstream development thinking, a new approach has emerged in the 1990s that emphasizes the role of institutions, political and economic incentives and the inter-relation between poverty, population growth and land degradation (Biot et al. 1995). It is clear that the latter two approaches have brought us a lot closer to developing culturally appropriate, integrated solutions to the problems of desertification and poverty. Still, there is a mounting body of evidence (e.g., Shaxson et al. 1989; IFAD 1992; Pretty 1995) that indicates that despite several shifts in research and technology transfer paradigms, soil and water conservation technologies have not been able to provide an effective cure for the perceived degradation problem (Mazzucato and Niemeijer 2000).

One can summarize that limited past impacts of agricultural research in desertification-prone areas stem from a wide range of problems, including not only the inherent biophysical challenges of development in desertification-prone areas (scarcities of water, organic matter, and nutrients) but in addition, policy and social factors such as: low priority for national investment; narrow, sectoral or disciplinary approaches; inappropriate or insufficient infrastructural and institutional environments; and lack of attention to the socio-economic context and client's priorities and decision-making processes (Rochette, 1989 ; Box et al., 1992; Leisinger and Schmitt, 1995; Bationo et al., 1998; Kerr, 2000; Pagiola and Holden, 2001).

A common failing that all these approaches share is that, in the absence of stakeholder consultation, they fall prey to conventional assumptions, such as that land degradation has already gone beyond the point of no return; that farmers are insufficiently aware of degradation processes; that traditional practices are not changing but disintegrating; that lack of financial resources limits the willingness and

ability of farmers to invest in land; that local institutions hinder rather than encourage land-enhancing measures; and that farmers are unable to cope with changing environmental and socio-economic contexts without outside intervention and transfer of (insufficiently tested) solutions (Mazzucato, et al. 2001). They also share a strong tendency to opt for a techno-economic approach, which seeks solutions in the technology and economic domains (Mazzucato and Niemeijer 2000).

A few case studies illustrate the types of difficulties encountered in past efforts, and illustrate principles and efforts that are leading to more successful outcomes.

Top-down watershed management

Kerr (2000) noted that Green revolution technologies designed for favorable areas were inappropriate for the dryland areas in India and as a result had little impact. Soil conservation practices were not adopted either, because they were incompatible with existing farming systems. He concluded that "successfully introducing better agricultural technology will require that agricultural research and extension systems increase their focus on clients and appreciate the complex and often location-specific factors that determine technology adoption. Land and water resources could be better managed by reforming outdated laws and bureaucratic procedures. Major government investments have had limited impact, in part because technocratic approaches have failed to address the fact that watershed development distributes benefits unevenly between upstream and downstream areas yet often requires universal cooperation."

He suggested that participatory projects are needed that involving farmers and with attention being given to social organizations, and observed that NGOs appear to be implementing this approach with initial success. ICRISAT and its partners in India are achieving good success now through participatory watershed development using a consortium partnership approach. Community needs and priorities are assessed through participatory interaction, while researchers help them understand the basis and drivers for problems, and possible avenues for solution. Through this interaction, the community develops an an action plan that they will implement themselves, aided by local and national government resources.

In the five years since the model was developed, it has been convincing enough to trigger a widening circle of impact and development investor support. From the first round of five watershed projects in 3 countries (Asian Development Bank-sponsored project), it grew to 20 (DFID-APRLP project), and now to 30, supported by a collection of six development investors from the international community, Government of India, and a philanthropic Foundation. This ripple effect is making significant impacts on incomes and also in communities' capacity to cope with recent severe droughts in Rajasthan and Gujarat.

Small-scale machinery: case of the broadbed and furrow maker

The vertisol technology, "broadbed and furrow maker", is an animal traction implement to overcome water-logging and enable earlier planting. First developed in Texas, it saw substantial R&D investment by ICRISAT and then ILRI over at least a 20-year period. There has been no impact in India where it was developed, and little has been achieved as well through south-south transfer to Ethiopia where adaptation was tried with farmer involvement in on-farm trials over a further 10-year period. In India, farmers were not sufficiently involved from the beginning, and eventually they

expressed that the BBM model being promoted was too expensive and heavy (Joshi et. al. 1998). The BBM was promoted by NGOs with subsidies to farmers and there were reports that a private manufacturer had sold about 8,000 units in Ethiopia and Eritrea, but the diffusion stopped after a few years and there is no clear evidence that even the 8,000 are still in use. This case illustrates the need to include careful cost-benefit analysis and farmer input in the early stages of machine design, considering issues of credit and competing demands for capital and draft power, and related farmer motivations.

Mis-valuation of crop products

Anecdotal evidence from farmers in SAT India has indicated that poor smallholder farmers operating under rainfed conditions are more interested in cereal stover for animal feed than grain due to the profitability and income from animal production activities. This was ignored until economists at ICRISAT did surveys throughout the SAT areas of the country and found the interest in dual-purpose sorghum was widespread (Asokan et. al. 1998). Now, together with ILRI, ICRISAT breeders are developing dual-purpose varieties. Increasing the digestibility of sorghum stover has become a target trait in the breeding program, following an extensive stakeholder consultation across South Asia.

Considering credit: fertilizer microdosing and warrantage in the Sahel

Based on on-station ICRISAT and partners recognized by the mid-80's that moderate levels of inorganic fertilizer (especially phosphorus) could substantially raise yields and lower the production risk, even for Niger's millet farmers in the semi-arid Sahelian region of West Africa (ICRISAT, 1984; 1985; 1986; 1987). On-farm fertilizer trials began on farmers' fields and showing promising results, fertilizer recommendations were developed for extension by NARS and NGOs to farmers (Bationo et al., 1993).

Economic analysis showed that technology adoption would lead to potential income increases of least 30% on average and bio-economic modelling corroborated this potential. Farmers were involved in the evaluation of the trials and although they acknowledged the technologies were better than their current practices, they said credit was needed to buy fertilizer (Shapiro, 1990). The researchers, though concluded that credit was not a constraint since the model results showed small ruminants could provide cash to purchase fertilizer (Shapiro, 1990).

Some diffusion took place in study villages so researchers expected widespread scaling out and up (Shapiro et al., 1993; Sanders et al., 1996). The results in terms of adoption and impact, however, were minimal. ICRISAT was criticized harshly for no NRM technology impact in West Africa after 20 years of substantial human and financial investment (McIntire, et al, 1995).

Believing that the credit constraint would not soon be overcome, researchers began to experiment with micro-doses of inorganic fertilizer combined with nutrients and organic matter from manure and crop residues (Shapiro and Sanders, 1998), but adoption still did not become significant.

Finally, FAO and NGOs went back to farmers and discussed with them again why they were not adopting fertilizer. Farmers again explained that credit was the constraint. This time FAO and the NGOs believed them and worked out with the farmers institutional and organizational innovations that would make adoption of

fertilizer possible. This has involved helping farmers start savings/credit associations that offer a combination of post-harvest credit and storage of grain as collateral (inventory credit or "warrantage"). This enables farmers to sell crops later in the season for higher prices and higher profits.

These changes finally have led to a significant technology breakthrough in Niger. For the last 3 years, about 330 farmer groups over 5,000 farmers have been using the micro-dosing/warrantage system to apply for the first small doses of fertilizer together with organic matter to their crops. In the process they have not only experienced yield jumps of 50 to 100 percent, especially in drought years (phosphorus advances crop maturity by 1-2 weeks, escaping the drought that punishes unfertilized crops), but they have also begun reversing a 30-year trend of declining incomes, and growing food insecurity and soil degradation. The micro-dosing/warrantage system is a huge success due to the close partnership of research, NGOs, and private sector banks with farmer groups and farmers (Abdoulaye and Sanders, 2001).

The micro-dosing/warrantage story shows that while poverty must be addressed to get farmers to adopt measures that protect the natural resource base (and environment), it is often not sufficient. Participation of farmers in technology development to understand their objectives and constraints is necessary, coupled with policy and institutional change to provide an enabling environment. It all starts with listening.

Improved land and water management in WANA

To be effective, technological developments need to be done in cooperation with the communities that are the target of such technologies. To this end the concepts of community action plans and negotiated action plans have been introduced into the eight countries of the Mashreq/Maghreb region. This program has thus successfully introduced technological packages to improve crop-livestock and pastoral production, catalyzed the development of community institutions and developed options for policy and institutional reforms for countries of the WANA region. The work is now ready to be moved to a pilot development project (Haddad and Eltom, 2002).

For example, in systems dependent on rainfall, these participatory efforts have been focused on introducing adapted crop and forage germplasm, technologies for rehabilitating degraded rangelands and improving water harvesting. In irrigated systems the focus has been on improving water use efficiency via supplemental irrigation (for example Oweis et al., 1999). With precise irrigation technologies it is possible to achieve 85-90% yields of fully irrigated crops with only 50% of the full irrigation water requirements (Oweis et al., 1997). At a landscape scale GIS techniques have been used to better target the placement of water harvesting structures in a watershed. With such technologies it is possible to grow high value tree crops such as almond and pistachios in areas receiving only 150 mm rainfall.

Substantial advances have also been made in improving the feed resources for livestock in integrated crop-livestock systems in the WANA region. These include new germplasm varieties for barley and forage legumes with large-scale demonstrations implemented in 8 countries of the Mashreq/Maghreb project. Spineless cactus has been introduced into several countries including Tunisia, Algeria, Jordan, Syria and Libya and is rapidly spreading as an alternative feed where there is a shortage and overgrazing of natural vegetation. Feedblocks produced from agro-industrial by-

products have been successfully introduced and replicated by the private sector in Iraq and are being developed by national programs and NGO's in Jordan, Tunisia, Algeria and Morocco with around 30 production units in place (Haddad and Eltom, 2002).

Despite the difficulties, progress does take place. Recent findings by Fan and Hazell (2000), for example indicate better returns on investment for agricultural R&D in the dry areas of India and China than in irrigated areas. One reason is that these areas had been historically neglected, raising the possibility that rapid gains may be possible in more desertification-prone areas, which have mostly suffered the same relative neglect. But another reason may be that research and development teams are learning from the past, and adopting more effective approaches.

Summing up – in reviewing the lessons of the past, it is clear that failures became opportunities to learn and revise the approach to sustainable development. This is still a 'work in progress' and a ripe area for innovative research and application of new concepts and approaches. One thing seems clear, though from the lessons of the past**: the *approach* to technology development and dissemination is as important, if not more so, than the technologies themselves.**

The DDPA has taken this basic lesson to heart – for example, the emphasis placed on an integrated ecosystems approach, the close linkage with the UNCCD policy and decision-making framework, and in the Consortium Pilot Areas as the operational crucible that will bring together researchers, community members, policy authorities, and other stakeholders who must work together for sustainable change. The DDPA attempts to combine the best of earlier approaches (e.g., participatory methods, attention to indigenous knowledge, integration of the institutional and policy dimension) with a holistic integrated ecosystems approach that:

- Investigates the occurrence, causes and effects of land degradation (rather than proceeding on general assumptions that may not apply in many particular circumstances);
- Views agriculture and agricultural production within the context of total ecosystems goods and services (rather than as a separate world);
- Considers technologies and peoples' actions within an institutional and policy context (rather than solely as a technical matter);
- Looks at genetic resources within the context of their on-farm use (rather than transferring models developed under very different conditions in other areas of the world);
- Looks at agricultural solutions as just one component of livelihood diversification strategies (rather than taking a purely sectoral perspective); and
- Recognizes knowledge and knowledge exchange as central resources in finding solutions (rather than just as a way to transfer new technologies to the farm).

Appendix IV. Relationships to sister Challenge Programs and Other Ongoing Programs/Projects

Water and Food CP

The core focus of the Water and Agriculture CP is in improving water management and water productivity in major irrigation systems, catchments and basins in both humid and dry areas. The DDPA will complement this with its focus on the integrated management of rainfed agro-ecosystems. There may occasionally be an interface or some potential for overlap where these dryland systems utilize rainwater harvesting or supplemental groundwater irrigation; these cases can be mutually discussed between the CPs. The Water and Food CP has also been discussing genetic components of drought tolerance. The DDPA proposes to place a strong emphasis on drought and salinity tolerance breeding for rainfed dryland crops and forages, given the deep experience and comparative advantages of the co-convening Centers (ICRISAT, ICARDA) in this area.

Agro-Biodiversity CP

The AB CP has a strong focus on developing methods for evaluating the linkage between all components of agricultural biodiversity (i.e., both above- and below-ground) and the ecosystem goods and services they provide. Close collaboration, possibly including common sites will be developed with this CP.

Genetic Resources CP

The GR CP focuses mainly on maize and rice, complementing the DDPA focus on millet, sorghum, barley, and related dryland crops, as well as important forage grasses and legumes. There will likely be similarities in biotech approaches to drought stress that would benefit from continuous sharing of ideas, knowledge, expertise, and techniques.

Climate Change –Beating the Heat CP

The DDPA focuses on the effects of climatic variability and extreme events (drought, flood etc.) whereas the Climate Change CP focuses on steady baseline shifts that could cause progressive changes in cropping systems over decades. These phenomena must be approached in different ways, although there will be areas of similarity and continuity. DDPA for example must emphasize risk management, early warning and emergencies, while CC must forecast and plan for shifts in entire cropping systems and ecozones. There may be overlap in the efforts on drought, livelihood diversification and poverty reduction in the Sahel in the current CP drafts that need to be discussed and coordinated.

Desert Margins Programme

There is a close relationship between the topical domains associated with the Desert Margins Programme (DMP) and the proposed DDPA, as might be expected. The Desert Margins Programme has been focused strongly towards the applied networking, adaptive testing and technology exchange end of the research-development spectrum, and works in Africa only; whereas the DDPA proposes an emphasis on research, and intends to be active in Asia as well as Africa. The clear

complementarities of these approaches form a strong starting asset for a combined effort under the DDPA umbrella.

The road map for integration is as follows. At present, two DMP entities formally exist: the CGIAR Systemwide Ecoregional Desert Margins Program (SE-DMP) and the newly-approved GEF-funded project entitled 'Desert Margin Programme Phase 1' (GEF-DMP), which is a project under the wing of the SE-DMP. Once the CGIAR approves the creation of the DDPA Challenge Program (DDPA), the DDPA will supersede the SE-DMP, absorbing and integrating its activities under the single governance structure approved for the DDPA. The GEF-DMP project will continue to have its project steering committee, but that will function under the overall management and governance structure of the DDPA.

LUCID

Lucid is an international group of scientists studying impacts of land use change in East Africa with a goal of providing scientific information to enhance economic productivity, ecological sustainability and environmental conservation. The current project funded by GEF through UNEP is entitled "Land Use Change Analysis as an Approach for Investigating Biodiversity Loss and Land Degradation". The project goal is to contribute to the conservation of biodiversity and prevention of land degradation by providing useful instruments to identify and monitor changes in the landscape associated with biodiversity loss and land degradation, and identify the root causes of those changes. LUCID's coordination is hosted at ILRI. ILRI is one of the co-leaders of the ecosystems Theme 2, which has a strong biodiversity element. LUCID will be brought under the umbrella of the DDPA, strengthening it in the areas of biodiversity and land degradation.

Mashreq-Maghreb Project

The IFAD-supported project entitled "The development of integrated crop-livestock production in low rainfall areas of Mashreq and Maghreb", led by ICARDA and IFPRI, has focused on the participatory development and validation of integrated systems technology packages to improve adoptability under favorable policy environments in 8 countries of the WANA region. The DDPA will build on this experience by absorbing its ongoing activities. In particular, efforts will focus on those communities that have already developed negotiated action plans. Options for up-scaling these approaches will be explored within the DDPA program and through links with the UNCCD.

Appendix V. Full profiles of the six research Themes

Theme 1 Understanding and Coping with Land Degradation and Drought Risk

Purpose

To develop more effective and scalable tools and methodologies to predict, measure and monitor land degradation and drought based on direct measures of the driving processes, states and impacts of degradation.

Rationale

To combat desertification means are needed to measure and monitor it over time. The complexity and interactivity of causal factors (see opening section on Defining the Problem), though makes land degradation a difficult parameter to measure.

Episodic drought further complicates the assessment of land degradation and its impact on livelihoods. Drought affects livelihoods through a reduced productivity of crops and forage. The reduced vegetative and residue cover diminishes soil productivity and accelerates degradation by exposing soils to increased temperatures, accelerated evaporation, and the erosive power of water and wind. Drought also increases the severity of the impact of land degradation on livelihoods and the desire of land users to avoid drought risk may in itself lead to coping strategies that increase land degradation and maintain poverty.

Currently there is no standardized and quantitative methodology for the measurement of the soil, water and biotic components of land degradation. Existing methodologies are either subjective or un-validated and are biased towards soil degradation (Scherr 1999; Scoones and Toolmin 1998, Mazzucato and Niemeijer 2000). Consequently, the studies that that provide information on land and soil degradation are few, are subject to difficulties of interpretation, and do not provide the level of detail that is required for policy development and land management (see for example Oldeman et al. 1991; Stoorvogel and Smaling 1990; Wood et al. 2000; UNEP 1997).

The 'first generation' approach, represented by the GLASOD survey (Oldeman et al. 1991) depended on expert judgment and was restricted to soil indicators; as a consequence, the assessments were of a subjective and qualitative nature, and did not take into account biodiversity and other ecosystem parameters.

The 'second generation', now in the planning stages, will be a new UNEP/FAO initiative for Land Degradation Assessment in Drylands (LADA) (UNEP/GEF 2001). It will use available data (satellite images, soils and vegetation maps etc) rather than expert judgment to assemble baseline maps at global, sub-regional and national scales, and will provide a standard methodology and guidelines for assessment of land degradation causes. However, this approach uses indirect or 'proxy' indicators such as vegetative cover, which are easily misinterpreted, rather than the degradative states and processes themselves. For example, productivity changes have sometimes erroneously been attributed to land degradation while in fact they were caused by (temporary) lack of rainfall or, in the case of agricultural land,

changes in socio-economic conditions that affected productivity. Significant areas classified as degraded are instead naturally poor, therefore not representing degradation.

The third generation approach, which we are proposing to develop in this Theme, would take a major step forward to include actual measurements of ecological state and impact variables – plus, frequent monitoring of those variables at much higher-resolution scales relevant for precise targeting of national development policies, such as small catchments and local government areas. This will bring a power of analysis to land management decision-making that is well beyond what has previously been possible. The emerging ability to provide timely, skillful precipitation forecasts offers the potential to adjust production and livelihood strategies to mitigate the direct impacts of drought events, and to invest in soil fertility and intensify production in years with favorable rainfall, with potential carryover benefits.

The methodology which this Theme proposes to develop relies on innovative statistical and spatial sampling strategies for field measurement (Mazzucato and Niemeijer 2000) and the use of inexpensive, frequent meteosat satellite data. This new energy-and-water-balance monitoring based technique (EWBMS) allows physiologically-based monitoring and quantification on a daily basis of plant growing conditions and biomass development (Rosema 1993). The ability to frequently monitor changes, supplemented by field assessments to judge the context of changes observed, should enable the development of a practical, affordable, and highly scalable methodology for conclusively diagnosing land degradation.

These physiologically-based assessment tools will then be combined with advances in modeling the ocean-atmosphere system to help to predict the agricultural effects of drought events several months in advance (Palmer and Anderson 1994; Hastenrath 1995; Goddard et al 2001) as a basis for drought coping strategies and land degradation mitigation. Combined with participatory assessments with communities on the ground, this will make more accurate estimation of the costs of land degradation and drought –information that can motivate decision-makers in weighing consequences and tradeoffs (De Groot et. al. 2002).

<u>Hypotheses</u>

1. Land degradation reinforces the impact of climatic variability on ecosystem productivity.
2. Monitoring and modeling of the climate system can produce advance information about the likelihood and severity of drought, which can lead to improved coping strategies both in years with enhanced and reduced drought risk
3. The distribution of rainfall versus actual evapotranspiration provides an indicator of land degradation.
4. Where no baseline data are available, the statistical analysis of differences in land quality of different land use types can reveal the degree of land degradation.
5. Integrating satellite monitoring and field measurement can provide quantitative information on land degradation and climatic variability at temporal and spatial scales relevant for policy and management decisions
6. Integrated analysis of the impact of land degradation and climatic variability on ecosystem productivity will lead to an understanding of causes and effects and therefore allow the development of appropriate solutions.

7. Valuation of the impacts of land degradation and climatic variability on ecosystem functions will allow weighing of economic and environmental interests for balanced decision making and thus create “win-win” solutions.

Objectives

1. Review and develop quantitative, objective, timely and affordable indicators to assess and monitor the pressures on, state of, and impact on dryland agro-ecosystems in relation to land degradation and drought
2. Develop affordable, scientifically sound, and replicable methodologies and tools to measure and monitor actual land degradation in drylands integrating field and satellite data
3. Evaluate the potential to predict shifts in the probability and severity of agriculturally important drought, at the scales that are important for drought and its consequences
4. Evaluate the consequences of predicted climate variations for aspects of the environment that are critical to drought response strategies and land degradation
5. Develop methodology and framework for a participatory valuation of ecosystem functions as affected by land degradation and climatic variation
6. Provide tools for improved monitoring and predictive information about drought and land degradation that policymakers and managers can use in discussing options different categories of stakeholders

Outputs

1. Rapid-assessment based hotspot detection methodology and tools to identify areas of likely degradation (for closer inspection)
2. List of affordable, efficient and scientifically-sound pressure, state and impact indicators for the soil, water, biotic, and productivity components of land degradation and climatic variability that can be used for monitoring in support of the UNCCD
3. Affordable, scientifically sound methodology, protocols and tools to measure and monitor actual land degradation in drylands integrating field and satellite data
4. Report on the predictability of agriculturally-relevant rainfall fluctuations and drought risk in the target regions and its impact on productivity and land degradation
5. Report on the potential impact on livelihoods and land quality if land user coping strategies are adjusted to improved information on climatic variability
6. Report on and maps of the degree and types of land degradation in the pilot areas using field and satellite based indicators, and relations between pressure, state and impact variables in the pilot area
7. Participatory valuation framework for the impact of land degradation and drought on dryland ecosystem functions
8. Validated and operational early-warning system for seasonal crop and grazing land productivity at local to continental scales

9 Training of local research partners and other stakeholders in generating, interpreting and using of predictive and monitoring information on land degradation and climatic variability

Initial core partners

EARS for remote sensing technology; the University of Wageningen for land degradation assessment expertise; and IRI for drought prediction (see profiles in Appendix VI), partnering with GIS capacity at ICRISAT and ICARDA as well as national and regional partners.

Theme 2 Integrated Ecosystem Approach for the Sustainable Provision of Agricultural and Ecological Goods and Services

Purpose

To improve livelihoods while enhancing ecosystem functions and conserving biodiversity through integrated ecosystem management

Rationale

Historically, interventions to improve the lives of the poor in arid and semi-arid ecosystems have been largely limited to sectoral-based initiatives. Efforts to increase agricultural productivity from a base of low inherent soil fertility have focused on component technologies such as soil conservation methods or the development of improved varieties of crop species. Rangeland management has received little attention and overgrazing is common. In the cropping and forestry sectors efforts have focused narrowly on increasing commodity productivity have resulted in large monotypic plantations.

The result has been an imbalance in land use and a gradually decreasing capacity of the drylands to deliver ecosystem goods and services on which local populations are dependent. Ecosystem goods and services include not only agricultural productivity but also the regulation of the availability and quality of water, efficient carbon and nutrient cycling, protection against erosion, the control of pest and diseases and conservation of genetic resources through maintenance of biodiversity[1]. In terms of biodiversity for example, "damage to land already cleared will ultimately eliminate 15% of the tree species contained in forests," according to McNeely and Scherr (2001). The loss of trees leads to losses of a wide range of associated biological resources such as invertebrates and micro-organisms, both above- and below-ground.

Yet, to achieve the sustainable use of drylands and improved livelihoods of the resident populations, "ecosystems must be managed as a whole, with protected areas as reservoirs of wild biodiversity within a 'matrix' of land managed to protect its habitat value, while also providing food and income to people" (McNeely and

[1] It should be kept in mind that not all ecosystem goods and services are positive. Natural brush is habitat for pests and diseases like tsetse fly which causes trypansomiasis, snails in natural lakes causing schistosomiasis, black flies near rivers causing onchosoriasis (river blindness), and mosquitoes that spread malaria. When beneficial ecosystem services cannot be preserved without the accompanying negative ones, the tradeoffs need to be understood and factored into management decisions.

Scherr, 2001). The non-equilibrium relationships between climatic and biotic variables in drylands mean that livelihoods in these areas have had to adapt to this constant high risk, either exploiting it through the mobility of pastoralism (Behnke et al., 1993) or mitigating it through the flexible pursuit of multiple livelihood strategies (Mortimore, 1998). The relationships of ecosystem degradation and recovery, or resilience, in this context need to be better understood for the drylands that are coming under increasing pressure from agricultural and other human activity. What is the tipping point at which degradation becomes effectively irreversible, what parameters trigger it, and how can it be averted?

Where desertification has severely impaired or degraded an ecosystem's capacity to deliver the balanced suite of goods and services needed to sustain livelihoods, there will be a need to invest in re-establishing ecosystem functions. Most of these services are biologically-driven, yet little is known about the relationship between the loss of any ecosystem function and changes in above- and below-ground biodiversity, nor of the requirements needed to initiate successional processes that will lead to the re-establishment of key functional groups that regulate and deliver the goods and services on which the people depend. We need a greater understanding of the role and interactions of different functional groups of organisms and especially those related to soil-based processes that are regulated by the soil biota.

Contrary to prevailing assumptions, the drylands are quite biodiversity-rich, as indicated in Table 2 (from White et. al. 2002.)

Table 2. Biodiversity indicators of drylands

Taxonomic/ Geographic Group	Global Total	Drylands Total	Percent of Global Total
Plant centers of diversity	234	39	17%
Endemic bird areas	217	103	47%
Terrestrial Eco-regions	138	31	23%
IUCN-recognized Protected Areas	5,495	1,406	26%

An innovative partnership is featured in this Theme. It will bring together agricultural and environmental organizations, through partnership with the Commission on Ecosystem Management of IUCN – The World Conservation Union. IUCN will advise and assist in the design and implementation of assessments and monitoring of the natural components of landscape-level ecosystems, and where needed, ecosystem restoration methods.

Hypotheses

1. An integrated ecosystem approach to ecosystem management will result in sustainable increases in productivity without an associated loss of ecosystem services and goods including conservation of biodiversity.
2. The loss or impairment of ecosystem services to society can be recovered through restoration/rehabilitation of capacities of components of ecosystems.
3. Early warning indicators of desertification can be developed through participatory approaches and used by land users to monitor and evaluate the state of the ecosystem.

Objectives

1. Jointly with Theme 1, determine the relationships between losses of ecosystem functions and desertification, and evaluate these functions and losses including both economic and non-monetary values.
2. Develop alternative models for managing mosaics of land uses to sustain total productivity of goods and services in different arid and semi-arid ecosystems.
3. Develop policy guidance and decision support systems for enhancing the provision of ecosystem goods and services from agricultural and natural components of landscapes.
4. Identify and communicate effective ecosystem restoration methods in ways that foster action to restore ecosystem capacities to deliver needed goods and services.
5. Enhance local stakeholders' capacities to manage complex landscape mosaics of agricultural and natural components.

Outputs

1. Frameworks for assessing and analyzing the capacities of different components of dryland ecosystems, including agriculture, livestock management, wood production, and natural areas and the trade-offs from different patterns of ecosystem use at selected sites.
2. Integrated soil and water management through soil surface management, better water harvesting, integrated soil fertility management and cropping strategies.
3. Tradeoffs and win-win opportunities identified and understood for sustaining healthy ecosystem functions and resources (particularly biodiversity-related) in relation to degradation/restoration dynamics of both managed and un-managed areas in the landscape, with careful consideration of issues of scale and larger societal needs and priorities, and in an integrated ecosystem context
4. Evaluations of outputs from managed and unmanaged land uses, including both economic and non-monetary values of environmental goods and services, useful for policy as well as research planning
5. Integrated ecosystem degradation monitoring tools and manuals developed and validated with land users (jointly with Theme 1)
6. Training modules and other knowledge-sharing resources developed (in close coordination with Theme 6) to increase awareness of ecosystem functions at key

stakeholder intervention points and scale levels (community, government, region, international)

Initial core partners

ILRI, IUCN-The World Conservation Union, ACNU, Univ. of Hamburg (Desert*Net BIOTA project-southern Africa), UNEP, ICARDA, TSBF/CIAT, SWMNet, ICRISAT, and many additional partners will be engaged in this integrative Theme.

Theme 3: Pro-poor Policy and Institutional Options for Combating Desertification and Drought

Purpose

Provide research-based information on policy and institutional options that can be useful in combating desertification, and to help strengthen the capacity of local and national governments to identify and implement such programs.

Rationale

The UNCCD has emphasized the critical importance of addressing socio-economic and policy factors, as inadequate attention to this contributed to the failure of earlier efforts to combat desertification (UNCCD Secretariat, 1995). Signatory countries to the UNCCD have committed to develop and implement national action programs to combat desertification, poverty and food insecurity in dryland areas.

Concerns about a downward spiral of land degradation and poverty in drylands and other fragile environments abound (Cleaver and Schreiber, 1994; Mink, 1993; Leonard, 1989; Durning, 1989). However, these problems are not inevitable, and can be ameliorated or exacerbated by the success or failure of policies and institutions to adequately adapt to changing circumstances such as rapid population growth, globalization, market development, technological change, climate change, and to these problems themselves (Scherr, 2000; Anderson, 1999; Lopez, 1998; Jodha, 1998; Prakash, 1997; Heath and Binswanger, 1996; Lele and Stone, 1989). There is increasing evidence of communities and households successfully adapting to these pressures, given a favourable policy and institutional environment (Templeton and Scherr, 1999; Leach and Mearns, 1996; Tiffen, et al., 1994). Nevertheless, in many cases successful adaptations do not occur (Lopez; Kates and Haarmann, 1992). There is thus a need for research to identify when and how policies and institutions should respond to the problem of desertification and the driving forces behind it.

The problems of poor people in desertification-prone areas are often compounded by risks and lack of access to resources, infrastructure, information, and appropriate technologies to maintain or improve productivity. Drought and other risks can undermine farmers' willingness or ability to invest in new technologies or conservation measures, especially if investments entail sunk costs and credit markets are imperfect (Fafchamps and Pender, 1997). Risks may also limit adoption of risky inputs such as fertilizer, reduce the effectiveness of input use due to forecast errors, discourage farmers from producing higher value (but riskier) commodities, cause farmers to adopt diversification strategies with lower expected returns or to hold low-return liquid assets as a buffer stock (Anderson, 2001). Limited access to roads and markets in many dryland areas reduce households' options for diversifying

farming activities and developing non-farm activities. Agriculture in such areas is often subject to either benign neglect or policies that encourage erosive farming practices (Hazell, Ngaido and Chaherli, 2002). Low agricultural output prices and market distortions in these areas often undervalue scarce resources and reduce farmers' profit, reducing incentives for investments in soil and other resource conservation.

Much has already been learned about the underlying socioeconomic and policy causes of land degradation in dry areas, such as population pressure, poverty, lack of access to markets, infrastructure, credit and other services, unclear land rights and land tenure insecurity, among others. For example, it is now well established that customary tenure systems can provide adequate incentives for sustainable land management (if not undermined by misguided policies), and can adapt to changing conditions (Otsuka and Place, 2001; Platteau, 1996; Place and Hazell, 1993). Other local institutions, such as social networks, also are important in determining whether farmers are able to practice a non-degrading form of agriculture in drylands (Mazzucato and Niemeijer, 2002).

However, much still needs to be learned to identify effective policy and institutional responses to desertification and drought and to the driving forces contributing to them. For example, it is not well understood under what conditions communal resource management institutions break down into unregulated open access conditions or evolve into effective institutions as population or market pressure increases -- therefore how government policies can effectively facilitate the transition to more effective, culturally fitting mixes of private and socially-oriented systems.

The synergies or conflicts between different interventions and the context-specific nature of impacts of policies and institutions are also not well understood (Pender, Place and Ehui, 1999). Lessons learned from research often tend to be site bound and not replicable to other regions. The difficulty of scaling up into national development strategies and scaling out to other communities will be important aspects of the proposed research program. Furthermore, the research will assess trade-offs and synergies among development outcomes such as agricultural productivity, poverty and environmental sustainability resulting from policy or institutional interventions.

Identification of these and other knowledge gaps will be based upon review of literature, field research and consultations with stakeholders (especially those involved in developing and implementing Action Programs for the UNCCD) and will be used to guide the research to ensure that it is addressing critical information needs.

<u>Hypotheses</u>

1. The failure of policies and institutions to adequately adapt to changing population, markets, technology and other factors is a major cause of desertification and worsening poverty in drylands.
2. Institutions tend to respond to changes in population, markets and technology that increase the demand for institutional change. However, institutional change may not keep pace with rapid changes and may be impeded by path dependency, power of vested interest groups, inappropriate policies, or other factors.
3. The problems caused by inadequate policy and institutional adaptation are exacerbated by the high risks facing households in dryland areas.

4. The prospects for reducing desertification, poverty and food insecurity in dry areas depends on pro-poor policies and investments in socially profitable mixes of social, physical, human and natural capital.
5. Socially profitable mixes of investments depend on the comparative advantage of different locations (largely due to differences in agricultural potential, access to markets and infrastructure, and population density).
6. In many dryland areas, the comparative advantages are more likely to be in livestock or tree products than in intensive crop production.
7. Programs to combat desertification are more likely to be successful if they facilitate policy and institutional changes that adapt to changing circumstances, are suited to the comparative advantages of different development domains, and provide incentive structures that promote resource stewardship and empower communities and households.
8. Trade-offs between the goals of reducing poverty and reducing desertification can be minimized by appropriate targeting, bundling and sequencing of policy interventions.

Objectives

1. Characterize and identify policy and institutional constraints hindering the successful implementation of desertification programs and identify promising policy and institutional options to combat desertification.
2. Develop a sound classification of development domains in dry areas to use for selecting pilot areas and help in scaling out and up research findings.
3. Evaluate the impacts of selected policy and institutional options on land degradation, poverty and food insecurity in different types of dry areas, considering the potential for “win-win-win” (productivity, poverty, environment) outcomes and likely trade-offs.
4. Document successes and failures for lessons learned, as well as carry out an overall evaluation of what past investments have achieved at an aggregate level.
5. Develop implementation guidelines for policy and institutional interventions.
6. Help develop the capacity of policy makers, policy researchers, and other stakeholders to develop effective national programs to address desertification, in line with the UNCCD.
7. Share information and knowledge with policy makers to inform on-going policy debates.

Outputs

1. A synthesis report on lessons learned from past studies and identification of gaps
2. A GIS database and report classifying target pilot areas into development domains and identifying focal points for launching sustainable economic development
3. A report documenting potential policy and institutional options for pilot areas
4. Research reports predicting impacts and trade-offs of alternative policy and institutional options for pilot areas

5. Consultations with policy makers and other stakeholders at local, national and international levels to share policy options and implementation guidelines
6. Trained research partners, stakeholders, local and national policy makers in use of policy tools and databases
7. Reports documenting the payoffs and factors affecting the returns from using scarce public funds to invest to reduce poverty and protect the resource base

Impacts of policy research

This research Theme will build upon the approach used by the Mashreq and Maghreb project led by IFPRI and ICARDA, which has been successful in achieving strong collaboration with local communities in dryland areas and with national agricultural research systems. According to the review mission for that project, the community approach "has been successfully adopted by practically all member countries", with numerous beneficial outcomes (Haddad and Eltom, 2002, p. 18-19). This community approach will be applied in the selected consortium pilot areas of this challenge program.

In the near term, this strategy is expected to influence the debate on policy and institutional options to pursue in national action programs and at local levels. It is expected that within the five years of the program, this Theme will identify several promising policy and institutional options to combat desertification and reduce poverty in each of the selected pilot areas and countries, that these options will be discussed in the policy debates in these countries, and that some of these options will be implemented.

It is not possible to specify in advance what options will be implemented, since this will depend upon the research and upon the policy process in the study areas. However, an example could be implementation of institutional changes on a pilot basis in study communities, such as changes in the free grazing system common in many areas to reduce overgrazing and promote investment, allocation of degraded common lands for private tree planting or other conserving uses, or experiments with alternative methods of extension delivery to increase farmer input and emphasis on local comparative advantages. Some of these types of policy experiments are already ongoing in some countries, and would be studied where feasible (and not already evaluated) to draw lessons about their impact and potential for scaling up, as well as to suggest additional policy experiments that would be useful.

As an example of this type of research and its potential impact, IFPRI has studied management and impacts of community and private woodlots in northern Ethiopia, where private woodlots are being established as part of a government policy experiment to allocate degraded lands for private tree planting. We have found that tree survival rates are higher on private than community woodlots, and higher on woodlots that are managed at a more local level, even though labor and other investments per hectare are greater for community woodlots managed at a higher level (Jagger and Pender, 2002). We have also found that involvement of the regional Bureau of Agriculture in promoting community woodlots reduces the effectiveness of collective action (Gebremedhin, et al., 2002). IFPRI's research in Ethiopia has also shown that the impacts of the current extension program are limited in the dry areas in the north due to heavy emphasis on promoting inorganic fertilizer use, which was found to be of low profitability in these areas; while

neglecting opportunities to promote improved livestock production, for which several profitable opportunities were identified (Pender, et al., 2002). These research results are having a significant influence on the current debate on use of community lands and extension policies in northern Ethiopia, though major changes in these policies have not yet occurred.

The program also could contribute to reforms of policies at a national level, such as changes in land policies, liberalization of market restrictions, or investments in infrastructure or market information systems. It is unlikely that major policy changes would result solely as a result of this research program, though the research could influence the debate and policy changes that occur. It also could influence the investment policies and strategies of governments and donor agencies, based upon identification of profitable investment opportunities to reduce desertification and poverty.

In the longer term, the impacts of this Theme will depend upon the impacts of the options implemented in the study countries, the increase in capacity to identify and implement such options in the study countries in the future, the extent to which successful options are publicized and taken up elsewhere, and the extent to which the conceptual framework and findings of the research influence the policy debate in the broader development community. Impact research would be needed beyond the 5-year time frame of the first phase of this program to assess such impacts, while continued outreach efforts would be needed to maximize impacts.

In terms of activities for spreading impact, the following will be pursued:

1. Working closely with decision makers and other stakeholders at local, national and international levels in defining, implementing and disseminating results of the research;
2. Linking this work to the ongoing processes of developing and implementing national action programs to combat desertification in the selected focus countries;
3. Building upon prior research on land degradation in dryland areas to the greatest extent possible;
4. Strengthening capacity of collaborators in study countries to identify effective options to combat desertification;
5. Conducting workshops at all levels to present preliminary findings and obtain stakeholder feedback that will be incorporated into the research products, before final results are disseminated; and
6. Producing multiple outputs from the research in formats suited to different types of audiences, including outputs targeted to policy makers (e.g., policy briefs and short policy reports synthesizing lessons learned) as well as publications oriented to the research community (books, journal articles, research monographs).

<u>Initial core partners</u>

IFPRI, ICARDA, and the University of Marburg-Germany (through Desert*Net) along with DRFN focusing on southern Africa.

Theme 4 Harnessing Genetic Resources to Combat Drought and Desertification

Purpose

Improve crop tolerance of and adaptation to drought and salinity stress through an integration of participatory, conventional, and biotechnological plant breeding approaches, integrating local genetic resources and knowledge with conventional and new-science methods.

Rationale

Drought and salinity are the two most prevalent abiotic constraints limiting crop and forage productivity in desertification-prone agro-ecosystems globally. Yet, conventional plant breeding and crop physiology have had limited success in building and deploying tolerance to these stresses in the developing world. There are two major reasons for this:

1. the complexity and variability of the environmental expression of these stresses invokes a similar complexity and variability of gene-controlled responses, which have been very difficult to standardize and select for in the field by conventional breeding;
2. the methodologies and institutional processes for plant breeding and seed dissemination used in industrialized countries (often called 'conventional' breeding), which are targeted towards environments where stresses are reduced and conditions are made homogeneous (through irrigation, agrochemicals, and monoculture) have been difficult to implement in poor areas of the developing world due to the poverty, lack of infrastructure, and the lack of supporting institutions, policies and processes that would be required to ameliorate the land quality and variability constraints.

Exciting recent advances in biotechnology hold promise to move forward against the first constraint. Scientists are finding that the genetic maps of different species within broad groupings (such as grasses) are surprisingly similar, a phenomenon known as *gene synteny*. This implies that genetic research and knowledge on widely grown crops that attract substantial research investment should also be applicable to improve the less-researched distant relatives of those crops. This Theme will attempt to capitalize on this opportunity for the crops of desertification-prone areas.

Comparative genetics tools in grasses (Devos and Gale, 2000), for example now make it possible to apply the collective genetic information from *all* of the species in these groups, to improve any *particular* species within that group—once a small set of basic genetic tools for that particular species is available. These basic tools are already available, or are well along in the research pipeline, for the crops and forages in the research mandates of ICARDA and ICRISAT.

This biotechnological approach does not use transgenic methods, which are controversial and could delay or impede the dissemination of research products for impact. It uses information and knowledge across wide species distances, rather than exchanging their genetic material.

Participatory plant breeding offers an opportunity to address the second challenge. Rather than avoiding complexity by developing uniform varieties that require a high-

cost homogenized environment, participatory breeding takes advantage of farmer's local crop genetic diversity, knowledge and skill in selecting lines that express an optimum combination of traits for the local environment. This approach also provides better varietal assessment in representative stressful environments, and facilitates more efficient marketing and dissemination of seed of varieties optimised for local conditions (Gisselquist, 1997; Rohrbach et al., 1997;Tripp, 1997; Witcombe et al., 1998). Just as important, participatory approaches provide a channel for feedback of farmer knowledge, priorities, and decision-making processes to plant breeding programs to increase their relevance and likelihood of success.

There have been few efforts so far to link the participatory, conventional, and biotechnological approaches, mainly because the participatory and biotechnological approaches are relatively new. The synergies from doing so are expected to be substantial. Participatory approaches will identify a wide array of locally appropriate germplasm to be targeted for improvement. ICARDA and ICRISAT hold the world's most extensive and diverse working germplasm collections of cereals and legumes adapted to the desertification-prone environments of the developing world, which will complement farmers' germplasm and open additional possibilities for improvement.

Molecular approaches will identify genomic regions in that germplasm that may enhance drought and salinity tolerance in ways not previously possible. The integration of molecular and conventional approaches will permit rapid and precise pyramiding of drought and salinity-tolerance-related traits within the locally-adapted, farmer-preferred crop and forage varieties. Participatory evaluation at many sites in farmers' fields should match appropriate gene combinations with relevant local stress complexes. This new collection of well-understood diversity, in turn will serve as an enhanced breeding resource for further rounds of improvement, and for use elsewhere.

Our non-profit collaborator 'The Institute for Genomics Research' (TIGR) has the technological base and facilities to enable characterization of homologous genetic markers for all of our target crops and forages. TIGR's bioinformatics unit has the personnel and experience to connect phenotype and pedigree information with gene expression and molecular genotype analyses. ICARDA is contracting with TIGR to develop a generic oligonucleotide-based microarray that can be adapted to allow allele-specific, high-throughput genotyping of any organism at marker loci associated with, or genes controlling, any heritable trait. These *stress microarrays* will have an expected operational cost of around US$10 per test (approximately 90% less than the commercial cost in the USA). Use of this innovative technology for developing countries will reside in the public domain.

Linking these biotechnological outputs to participatory approaches will not be difficult. The knowledge and technology channels to consortium pilot areas established in a sister Theme, combined with ICRISAT's bioinformatics capability, provides the Program with a strong comparative advantage for the implementation of internet-accessible integrated plant genetic resources databases. These databases will be a major international public good arising from this Challenge Program.

Hypotheses

1. Gene synteny information will enable important genetic insights that can be effectively applied to enhance drought and salt tolerance;
2. The integration of participatory, conventional, and biotechnological approaches to plant breeding for marginal drought-prone agro-ecologies will generate valuable synergies and overcome technical (the difficulty of breeding for unpredictable, non-uniform, stressful environments) and procedural obstacles (of the industrialized-country plant breeding model);
3. In stressful rainfed environments, crop and forage varieties developed for specific locations will perform better than varieties developed for global mega-environments (i.e., epistasis and genotype × environment interactions are important).

Objectives

1. Develop an integrated approach for efficiently exploiting the advantages of conventional, biotechnological, and participatory plant breeding methods to combat desertification, drought, and salinity.
2. Develop haplotype databases, stress microarrays, and bioinformatics tools for the Triticeae, Panicoideae, and Leguminoseae to identify and map genes and QTLs contributing to tolerance of and adaptation to drought and salinity stress.
3. Characterize physiological pathways found in germplasm donors differing in mechanisms of tolerance and adaptation to drought and salinity stress.
4. Use phenotyping data with approaches from objective 1 and outputs from objectives 2 and 3 to breed crop and forage germplasm pools better adapted to fragile, drought-prone and desertification-threatened agricultural landscapes of arid and semi-arid Africa and Asia.
5. In partnership with NARES (including public, private, and NGO partners), disseminate improved crop germplasm that better meets farmers' needs in fragile arid and semi-arid Africa and Asia.

Outputs

1. Haplotype databases
2. Drought and salinity stress microarrays
3. Crop genome databases linked to genetic resources databases and stress phenotyping databases
4. Information on genes, QTLs, and linkage maps, in databases and published
5. Alternative stress tolerance pathways described
6. Sources of salinity stress tolerance and drought stress tolerance identified and characterized that differ in their genetic-mechanistic-physiological bases in target crops
7. Improved breeding populations having locally preferred traits in more salt and/or drought tolerant genetic backgrounds
8. Direct comparisons of efficiency of component approaches and integrated approaches

9. Experimental and released cultivars
10. Germplasm and seed exchange
11. Feedback to integrated breeding programs from participatory trials via biotechnological tools

Initial core partners

ICARDA, ICRISAT, CAZS (participatory methodology), TIGR (oligonucleotide microarrays), CERAAS (drought-West Africa), ICBA (salinity).

Theme 5 Income-Increasing Agricultural Diversification to Improve Livelihoods and Foster more Sustainable Land Use

Purpose

Create agricultural diversification prototypes, processes, models and options to increase and stabilize incomes of the poor while improving agro-ecosystem robustness and complexity, including participatory methods that build capacities for sustaining and extending these gains over time.

Rationale

The DDPA's twin goals of building livelihoods (especially reducing poverty) while saving lands are closely interdependent, because farmers will only invest in land restoration when they perceive that by doing so their livelihoods improve in some way, especially through greater and more stable incomes (Sanders, Shapiro, and Ramaswamy, 1996). Without more profitable alternatives, land-degrading practices in dry areas including soil nutrient mining, organic matter depletion, overgrazing of livestock, and deforestation will continue to the point of land abandonment.

The cultivation of commodities such as cereal grains is only marginally profitable in very dry areas, and is plagued by declining yields as soils are mined. Large annual fluctuations in production due to drought, a high risk due to overdependence on just a few crop options, and large fluctuations in value due to limited export potential and infrastructure also trap farmers in a cycle of insecurity and poverty (Leisinger and Schmitt, 1995; Mokwunye et al, 1996; Bationo et al, 1998;Groot et al, 1998; Smaling E.M.A et al, 1997).

Non-agricultural alternatives such as eco-tourism have been drawing much attention recently, yet it is not clear that they provide a broad opportunity for the large numbers of poor residing in these zones. These poor are mostly involved with agriculture at present, and building on their often-ignored agricultural knowledge assets and skills might reduce poverty more widely and equitably. Therefore a search for more and higher-value agricultural options is an important line of investigation for poverty reduction in marginal areas (Sanchez et al., 2001; Kerr et al., 2001).

Diversification research to date has mainly focused on higher-rainfall agroecosystems in the humid zones, both in Asia and Africa. There has been an assumption that the potential for diversification is less in the dry areas, but this has not been carefully tested. As explained in the Ecosystems Theme, the natural biodiversity assets of dry

areas are greater than most realize. The total quantity of biodiversity assets may be less relevant than how effectively they are used, including the judicious introduction of external biodiversity. The previous neglect of developing agriculturally related biodiversity resources in dry areas might create a significant opportunity for rapid gains and high returns from research investment in this Theme.

Diversification simultaneously holds the potential to rebuild important ecosystem features and capabilities. It creates ground cover for soil protection, soil fertility (including organic matter and micro-organism diversity), microclimate, habitat, and others. The *planned* addition of new species to an agro-ecosystem also creates new niches that stimulate colonization by *unplanned* biodiversity, below- as well as above-ground, triggering a rapid scale-up in system diversity and resilience. In any given landscape, different farms will be at different stages of diversity at any given time, creating a mosaic of patches that could render landscape areas more ecologically as well as economically stable than current cereal-dominated landscapes.

Gains in human capital through encouraging more biodiverse systems are also of major significance. Diversification creates an opportunity for engaging farmers in the participatory development of ways to capture greater value from their own knowledge and skills, since they are the most familiar with the natural resource assets of their agro-ecosystems, including wild harvests from indigenous species. Through participatory knowledge-sharing and experimentation, farmers become central players in the domestication of high-value wild species; the development of integrated agro-ecosystems; and the startup of associated small agro-enterprises needed for input supply, services, and output marketing of new products, all stimulating indigenous economic growth and self-reliance.

Simultaneously, farmers and communities become engaged in the restoration of their own lands, strengthening their natural resource management capabilities and awareness. As they heighten their appreciation of the inherent value of their natural resource base and knowledge, they become motivated to invest greater effort in its preservation for the longer term.

In addition to indigenous biodiversity, there is enormous potential for adapting 'exotic' biodiversity from other regions. The greatest impacts in the history of agriculture have arisen from trans-continental exchanges of crop species, such as potato, tomato and corn from the Americas to Europe and Asia, wheat and barley from Asia to the Americas, and many others. As an international organization, the CGIAR can clearly contribute strongly to international exchanges of such germplasm, technologies and knowledge, and helping communities handle complex issues related to ecological fitness and aggressiveness, phytosanitation and effects on pest complexes, intellectual property rights etc.

This Theme will seek diversification strategies that can increase incomes while reducing risk and protecting or enhancing environmental goods and services. Promising avenues for exploration include the integration of higher-value crops, trees, and livestock into more diverse and complex, multi-storied 'garden' agro-ecosystems yielding a more diverse and reliable stream of products over the annual cycle. The potential for tapping diversity-within-diversity, i.e. the wide range of products yielded by even single species or system components, including valuable intraspecific genetic diversity, will also be explored.

To elevate the baseline productivity of these areas, the agronomy and affordability of smallholder-appropriate enhancement of the resource base through practices such as the targeted correction of soil infertility bottlenecks, water harvesting and supplementary irrigation where local water sources are inexpensively available but under-utilized, and necessary crop protection practices will also be studied. Constraints to credit and capital management required to implement diversification strategies will also be studied. Input supply and output market channel issues will also be tackled, since they are critical for the sustainability of new agricultural production systems. Ways to increase incomes through smallholder enterprises allied to these infrastructural and value-addition services will be sought, rather than building solutions around a dependence on costly imported inputs or foreign input, service and marketing agencies.

Selected high-impact opportunities for diversification in the dry areas:

- Multi species/strata compound market gardens and food banks using low-pressure drip

Hypotheses

1. Agriculturally-valuable indigenous biodiversity exists and holds significant economic potential even in the dry areas
2. More diverse agricultural systems will improve total system productivity, resource use efficiency, income, and stability while reducing risk in the dry areas
3. More profitable agricultural options will motivate farmers to invest in maintaining land productivity and ecosystem services, and even in restoring degraded lands
4. The capital investment requirements for diversification can be kept modest and managed in ways accessible to smallholder circumstances through innovative credit and related systems
5. Farmers will be willing and active participants and will contribute valuable knowledge and skills in the collaborative development of more diverse systems including the domestication of indigenous species
6. Markets, including export markets, can be developed that profitably link even the dry areas to remunerative outlets for more diverse types of produce
7. A major portion of the value added from diversification can be captured by local small enterprises that benefit the dry areas, rather than by external agencies

Objectives

1. Create/adapt and test development process models that engage farmers and communities by building on both traditional and new knowledge and practices that lead to enhancing diversity, increasing incomes, and maintaining/restoring agro-ecosystem functions.
2. Apply such models to review, analyse, co-develop with farmers, and disseminate prototype diversified land-use systems.
3. With farmers, identify and test tree-, crop- and livestock-derived products that are marketable and hold the potential for sharply higher incomes for the poor.

4. Develop input supply and market-chain models that foster value-addition, involving local-scale agro-enterprises that retain a large proportion of the benefits at community levels.
5. Assess and interpret integrated system effects and outcomes, including productivity, livelihood, sustainability issues, through models that integrate biophysical, social, agricultural and natural-ecosystem resources and products (including ecosystem goods and services), and publish lessons learned.

Outputs

1. Development process models that foster the participatory development of agricultural livelihood diversification options for the poor in desertification-prone areas
2. Prototype farming systems that are more diverse, stable and productive than prevailing cereal-based systems for the desertification-prone areas
3. New or enhanced, higher-value agricultural products identified and understood
4. New input-supply, services and marketing system prototypes and models
5. New prototype agro-enterprises that create income-earning opportunities for the poor
6. Analyses and reports that enable impact assessment, trade-off comparisons, and guidance to similar initiatives elsewhere

Initial core partners

ICRAF, ICRISAT, ICARDA, ACNU, IFPRI, IPALAC

Theme 6 Breaking Technology and Knowledge Barriers: Increasing Impact with an "ICT for Development" Strategy

Purpose

Generate technology and knowledge (TK) assets, channels, processes, and mechanisms that can substantially enhance the flows of information and knowledge that are essential for sustainable development of the desertification-prone areas, with a special focus on exploiting the possibilities of new information and communication technology (ICT).

Special note: this is a crosscutting Theme. The *application* of these innovations for disseminating TK conceptually resides in the other five Themes. Operationally, all six Themes will work closely together to co-evolve effective models for TK-sharing.

Rationale

Unlike single-factor technologies or 'magic bullet' solutions, an integrated ecosystem approach to building livelihoods and saving lands is a knowledge-intensive venture. System-based interventions require an awareness of interacting factors, options, tradeoffs, balances, and similar knowledge-rich issues. This is one reason for the limited impact of much desertification research to date (UNCCD-COP5, October 2001).

Desertification-prone areas also suffer from a number of particular circumstances inhibiting knowledge exchange. They are frequently distant from the coastal mega-cities and less exposed to global information flows. They are less likely to speak one of the common global languages. Too often, they lie on the have-not side of coastal/inland, urban/rural, and rich/poor cultural and economic divides. They tend to receive less priority from governments due to a perception of lesser development potential, causing them to fall even further behind over time.

The dynamism and changeability of community structures in these areas also creates impediments to TK-sharing. Confrontations between sedentary vs. nomadic activities and between national vs. traditional governance structures spark conflicts that often push people apart, breaking the trust that is essential for TK-sharing. Transhumant and employment-related migration alters community structures over short time frames, and interacts with land-tenure, gender, household, and other social characteristics in ways that make TK-sharing more difficult.

Regardless of these difficulties, the peoples of these zones must be the centrepiece of sustainable action to combat desertification. Not only is their welfare a primary concern in and of itself; they also hold TK resources that are invaluable in the search for solutions. Traditional TK interacting with contemporary TK can help partners think 'outside the box' to come up with new yet appropriate practices.

Likewise, institutional stakeholder groups such as governments, NGOs, private-sector, national, regional, international, and academic groups have their own cultures and norms of TK-sharing. Often, sharing takes place within, but is limited between groups. These constraints significantly impede sustainable development. Communities must be able to exchange views with governments, and agriculturalists must listen to and learn from environmentalists, for example. Scholars, researchers and practitioners associated with the core disciplines that will engage in this Challenge Program – related to agriculture, livestock management, forestry, and ecology – have traditionally operated in isolation, and too often there are difficulties in accessing TK across these domains. Therefore, an important element will be the development of knowledge management capacities that facilitate exchange of such information across the disciplines and scale of users.

Technical factors are only one part of the problem, of course but revolutionary new approaches are now possible that could fundamentally change the equation. The CGIAR Systemwide review exhorted the System to harness the extraordinary recent advances in information and communication technology (ICT) to enable transversal and non-hierarchical flows of information (Recommendation 6, Third System Review of the CGIAR, 1999). This will be a focal point of research and innovation in this Theme.

The rural telecenter strategy has shown great promise when appropriately implemented (PANTLEG 1999; UNDP 1999), providing a knowledge exchange platform that can benefit the poorest in villages that are remote and lacking basic infrastructure such as telephone land lines and electricity. The approach has garnered praise from the world press (Dugger 2000a and 2000b; The Economist, 2001; Reich, 2000). Skilled facilitators and community coordinators are needed to serve as community intermediaries, and they can play the additional role of liaison and facilitator of the Stakeholder Dialogue aspects at consortium pilot areas. Such skilled personnel will be found through an innovative partnership with the United Nations Information Technology Service (UNITeS), a global e-volunteer mechanism

launched by UN General Secretary Koffi Annan in April, 2000 to help bridge the 'digital divide' (www.unites.org).

In this effort, we will take advantage of existing experience, mechanisms and resources. The UNCCD has created a framework for knowledge exchange to and from the national, sub-regional and regional levels, through the identification of national nodal points and the development of Action Plans (NAP, SRAP, and RAPs) and Thematic Programme Networks (TPNs) for combating desertification. Existing and prior TK initiatives in South and East Asia will also be integrated and built upon.

The Desert Margins Program (DMP) convened by ICRISAT in Africa has over the last decade placed major emphasis on establishing TK-sharing channels and mechanisms, and using those mechanisms to ensure stakeholder involvement in finding solutions. The Mashreq/Maghreb project convened by ICARDA across the Middle East and North Africa has demonstrated that participatory research involving all dimensions of the stakeholder community can succeed in desertification-prone areas of WANA.

Hypothesis

Our central hypothesis is that constraints to effective communication and TK flows among stakeholder groups in the past have been major impediments to building livelihoods and saving lands in desertification-prone areas.

Objectives

1. Create platforms for stakeholder communication and knowledge exchange, including a DDPA Stakeholder Dialogue process.
2. Create integrating mechanisms to make available what is already known in DDPA-related research, as a resource for both stakeholders and research partners.
3. Assess and map TK flows and cultural impediments to flows among key DDPA stakeholder constituencies, and devise ways to overcome bottlenecks.
4. Test the rural telecenter concept as a means to overcome barriers of distance and infrastructure to enable vital technology and knowledge exchange among DDPA stakeholders.

Outputs

1. Design and implementation of an ongoing Stakeholder Dialogue process to ensure for participatory evolution of the DDPA's agenda, and to ensure continuing understanding and ownership of its priorities, processes and outcomes.
2. An easily accessible, user-friendly internet system and associated processes for integrating global, regional, national, and community TK resources related to the Program's domain of work.
3. A knowledge flow map and knowledge network analysis identifying and providing an understanding of flows and blockages among key partners and stakeholders, and devise & test means of easing them.
4. Rural telecenter models developed and piloted based on community ownership and participation.

Initial core partners

ICRISAT (telecenter pilot expertise), IDRC (global telecenter assessments and insights), UNV (community e-volunteers as TK intermediators), DRFN (community participation and TK exchange expertise)

Appendix VI. Comparative advantages of some committed partners in the DDPA

National and regional bodies

CERAAS (Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse) is a unit of the National Agricultural Research Institute of Senegal and a regional base-centre of the West and Central African Council for Agricultural Research and Development (CORAF/WECARD) for the study of crop adaptation to drought. CERAAS holds competence in drought early warning indicators and the genetic improvement of drought tolerance. It has state-of-the-art laboratories and equipment and 10 hectares of experimental fields with controlled irrigation to simulate drought stresses. It has close partnerships with advanced research institutions and regional centres such as AGRHYMET, and the 9 drought-affected countries of the Sahel zone.
CERAAS also trains NARS scientists including technical diploma, masters and doctoral degree programs.

The NARS is well developed in **India** and is implemented through a number of research institutions under the umbrella of ICAR (Indian Council for Agricultural Research) and SAU (State Agricultural Universities). The ICAR institutes have the infrastructure and skill to undertake any program on combating desertification and controlling land degradation in India in OFR-PTD mode, with the collaboration of stakeholders. Controlling land degradation is basically under the preview of **CAZRI**, **CRIDA**, CSWCRTI, CSSRI, NBSSLUP and SAU in the region. Research and development in the field of combating desertification was initiated during 1952 and significant progress has been made over the last 50 years. Technologies for controlling wind and water erosion, sand dune stabilization, reclamation of saline/alkaline lands, alternate land uses, water management, and rehabilitation of drastically degraded lands were developed and implemented over large areas.

INSAH is an institution of CILSS in charge of facilitating the coordination of research in across its nine member countries. INSAH, as endorsed in CORAF's strategic plan, is also responsible for coordinating national research in the Sahelian zone. INSAH is also the lead organization for the West African and Tchad SBRAP thematic group on scientific and technical cooperation. INSAH is or has been involved in many research and development regional programmes dealing with the UNCCD convention. The NRM Pole, an on-going regional scientific cooperation programme, is a framework for synergy and complementary for all initiatives in this region dealing with environmental and development problems. It can function as an implementation agency for the DDPA in the Sahel region.

The Soil and Water Management Research Network for East and Central Africa (**SWMnet**) is a research networking organ of the Association for Strengthening Agricultural Research in East and Central Africa (ASARECA). SWMnet brings together all NARS in the region and has the mandate for coordinating the NRM strategy of ASARECA. Its strategy focuses on "Improving the management of soil, water, vegetative and livestock resources for economic growth and sustainability". Even though SWMnet is still in its formative stages, it will probably be the leading coordinating body in research related desertification the region.

Advanced Institutions and Universities

The Agroforestry and Novel Crops Unit (**ACNU**) of the School of Tropical Biology at James Cook University (JCU) in Cairns, Australia focuses on the development and implementation of a package of domestication techniques for the propagation, selection, breeding and cultivation of trees indigenous to the dry and moist tropics. This tree domestication package is being applied to species for the improved production of timber and non-timber forest products within agroforestry systems in Africa, Asia and Latin America to enhance the livelihoods of subsistence farmers, generate income, diversify farming systems and increase the sustainability of agricultural systems. ACNU is led by Prof. Roger Leakey who has pioneered the domestication techniques and strategies for tropical trees. While working for ICRAF (1993-97), he initiated a global programme for the Domestication of Agroforestry Trees, with dryland projects in the Sahel (based in Bamako, Mali) and in southern Africa (based in Malawi). More recently, from Australia he has been working in Namibia and South Africa on the domestication and commercialisation of Marula (*Sclerocarya birrea*).

The Center for Arid Zone Studies (**CAZS**), an independent natural resources research, teaching and consulting group within the University of Wales, Bangor, is a leader in the environmental field. It has particular expertise in institutional development and capacity building, plant stress (particularly participatory crop improvement – breeding and agronomy – and salinity), and the effects of global change on rangeland biodiversity and community livelihoods. It has specific experience in the development of cultivar databases to assist in participatory breeding, and in the production of databases of "grey" literature reviewing previous agricultural research in developing countries as a tool for capacity building. It also has extensive expertise in the development of participating plant breeding and variety selection, and its integration with conventional breeding and biotechnology.

The German Competence Network for Research to Combat Desertification (**Desert*Net**) integrates a wide spectrum of disciplines and scientific institutes with long-term experiences in more than 40 countries. Desert*Net, as a network of scientists and experts, can give advice on scientific methods and projects and can promote cooperation between and to institutions in Germany working in various fields of desertification research. Interdisciplinary work on land degradation and desertification is currently being carried out in the interdisciplinary research project BIOTA BIOTA Southern Africa is a co-operative research initiative on biodiversity aiming at creating a significant contribution to the international Convention on Biodiversity (UNCBD) and UNCCD. Desert*Net also works with the IMPETUS-Project (Integrative Management Project for the sustainable utilisation of water in Morocco), and is intensifying is collaboration in the North Africa & Sahel areas. Member institutes and research projects have also worked on desertification and food security in Pakistan, Sudan, Botswana, Israel, Egypt, and Brazil. We are planning a research partnership in China is also being planned.

EARS (Environmental Analysis & Remote Sensing) is a private-sector firm in the Netherlands specializing in remote-sensing research and development. It is involved in a number of international remote sensing projects including the use of new analytical tools for crop yield forecasting in Africa, China and Europe. It operates its own METEOSAT satellite data receiving system. Using daily METEOSAT imagery it has developed the continental scale Energy and Water Balance Monitoring System

(EWBMS). This System is the first in the world to generate spatially continuous and quantitative actual evapotranspiration data, which is the key to the quantification of drought and crop yields and the estimation of irrigation needs.

The International Center for Biosaline Agriculture (**ICBA**), a CGIAR Partner, is an international applied agricultural research and development center, located in Dubai, UAE. Its objective is to develop and promote sustainable agricultural systems that use saline water to grow crops, forages, trees and vegetables in arid, semi-arid and sub-humid regions. ICBA is the only international centre in Africa and Asia focusing solely on saline soil and water issues related to agriculture. With a mandate covering counties in arid, semi-arid and sub-humid regions and strong donor support for its programs of plant genetic resources, biodiversity and natural resources, ICBA is uniquely positioned to make a significant contribution to the DDPA. It has the support and confidence of many important donors such as Islamic Development Bank, IFAD, OPEC FUND, ADB, AFSED, UNEP, AAAID and UAE.

IPALAC, the International Program for Arid Land Crops, was created in order to assist the development, transfer, adaptation, and dissemination of crops and trees, as well as small-scale drip irrigation for arid lands. Its present focus is semi- arid Africa. IPALAC is administered by the Ben Gurion University of the Negev, Israel. It is supported by the Finnish Ministry of Foreign Affairs, by MASHAV-the Israeli Centre for International Cooperation, the Ben Gurion University, and private foundations. ICRISAT, the DMP, and IPALAC have been cooperating since 1997 in joint execution of programs aimed at the transformation of Sahelian agricultural systems.

The International Research Institute (**IRI**) for Climate Prediction, based at The Earth Institute at Columbia University (USA), seeks to enhance society's capability to understand, anticipate and manage the impacts of seasonal climate fluctuations, in order to improve human welfare and the environment, especially in developing countries. The IRI accomplishes its mission through strategic and applied research, education and capacity building, and provision of forecast and information products, with an emphasis on practical and verifiable utility and partnerships. By orchestrating a network of collaborative programs that couple physical science research and applications research with capacity building, the IRI plays a unique role in the international development of applications of climate prediction.

Founded in 1992, The Institute for Genomic Research (**TIGR**) is a not-for-profit research institute whose primary research interests are in structural, functional and comparative analysis of genomes and gene products from a wide variety of organisms. TIGR has since completed the genome sequence of many pathogens (disease-causing bacteria) including those that cause cholera, tuberculosis, meningitis, syphilis, Lyme disease, and ulcers. TIGR is one of the original centres that conducted large-scale human genome sequencing on Chromosome 16. TIGR is involved in numerous collaborations in developing countries including with the International Livestock Research Institute (ILRI) on the sequence determination of the genome of a parasite that causes East Coast Fever, a fatal disease of cattle in sub-Saharan Africa. Through their joint efforts, researchers hope the results of their work may then lead to improved treatment not only of East Coast Fever but also of malaria, cancer and other deadly diseases.

Building on many years of experience, **Wageningen University** is well known in the fields of agricultural and environmental studies in the tropics. The university not only covers, but also integrates a wide range of social and technical disciplines. In relation

to the DDPA, there is a lot of expertise in the Department of Environmental Sciences on soil nutrient modelling, land degradation measurement and the assessment and valuation of ecosystem functions. Research groups such as the Environmental Systems Analysis Group take an integrated systems analysis approach to analyze and solve issues of sustainable development.

CGIAR Centres

ICARDA through its partners has developed a series of integrated management strategies via participatory approaches that incorporate technological interventions into a matrix of production systems and available water resources in the dry areas of CWANA. In systems dependent on rainfall efforts have been focused on introducing adapted crop and forage germplasm, technologies for rehabilitating degraded rangelands and improving water harvesting. In irrigated systems the focus has been on improving water use efficiency via supplemental irrigation. The concepts of community action plans and negotiated action plans have been introduced into the eight countries of the Mashreq/Maghreb region, and are now ready to be moved to a pilot development project.

The International Centre for Research in Agroforestry (**ICRAF**) is a world leader on developing improved agroforestry systems. Its Sahel Program based in Mali focuses on promoting sustained agroforestry-based agricultural productivity that will reduce risks for small-scale farmers, improve income, and reverse land degradation and desertification. The Sahel Program operates through formalized network of partners operating as consortia within selected priority land use systems in the Sahelian countries. ICRAF's Southern Africa regional program also covers dryland areas.

ICRISAT has a mandate to improve the crops and systems of the semi-arid tropics. It has experienced teams based in highly desertification-prone areas such as Niamey (Niger) and Bulawayo (Zimbabwe), and its headquarters is located near a degradation-prone area in central India, where watershed management research is a focus. Among natural resource management topics, ICRISAT holds particular expertise in soil, water, nutrient management, geographical information systems, and socioeconomics & policy. Knowledge management and rural ICT telecenter development strategy are also a core competence. In the genetic resources arena, ICRISAT boasts expertise on drought tolerance breeding for sorghum, pearl millet, chickpea, groundnut, and pigeonpea.

Through its policy analyses, **IFPRI** indirectly affects policy changes through opinion leaders, donors, advisers, and media who influence national and international decision-making. IFPRI's Environment and Production Technology Division conducts research on development strategies for dryland areas, the causes and effects of agricultural change in fragile lands, risk management, and priorities for public investment in agriculture. This includes research the links between property rights, adoption of technology, investment, productivity, and rangeland management in low-rainfall areas.

The International Livestock Research Institute (**ILRI**) has conducted long-term research in rangelands across Africa with a current focus on how to balance wildlife conservation with pastoral welfare in these systems. Over the past 10 years, ILRI scientists have studied the driving forces of land use change such as the role of livestock in desertification, and the impacts of those changes on productivity,

biodiversity, soils and vegetation across Africa. Most recently a GEF-funded partnership known as LUCID (Land Use Change, Impacts, and Dynamics) led by ILRI is investigating biodiversity loss and land degradation in East Africa, providing a capacity especially relevant to the DDPA.

The Tropical Soil Biology and Fertility Institute of CIAT (**TSBF-CIAT**) was founded with the aim of promoting the biological management of soil fertility as an essential component of sustainable agricultural development. The Institute aims to develop 'adoptable and sustainable soil management practices that integrate the biological, chemical, physical, social, cultural and economic processes that regulate soil fertility and optimize the use of organic and inorganic resources available to the land-users'. The Institute is the executing agency for a seven-country UNEP-GEF-funded project on 'Conservation and sustainable management of below-ground biodiversity'. This project will provide valuable inputs to Theme 2 of the DPPA. TSBF-CIAT is also the convening centre for the CGAR Systemwide Programme on Soil, Water and Nutrient Management and will act as a conduit for the contribution of a wide range of partners to the DDPA CP.

Non-Governmental Organizations

The **Desert Research Foundation of Namibia (DRFN)** is an NGO working closely with the Ministries of Agriculture, Water and Rural Development and of Environment and Tourism as the major implementing agent of Namibia's National Action Programme to Combat Desertification (under the UNCCD framework) since its inception in 1994. Under SADC-ELMS on behalf of the UNCCD, the DRFN at Gobabeb has been appointed a centre of excellence for training and research in the region. The DRFN is involved with long term research and community interactions focused on Namibia's drylands: local level indicators and monitoring including deforestation and rangelands; institutional development and communication amongst rural communities, service organisations and decision makers from local to the national level.

IUCN – The World Conservation Union was created in 1948. It brings together 72 States, 107 government agencies, 743 NGOs, 34 affiliates, and some 10,000 scientists and experts from 181 countries in a unique worldwide partnership. IUCN's mission is to influence, encourage and assist societies throughout the world to conserve the integrity and diversity of nature and to ensure that any use of natural resources is equitable and ecologically sustainable. The Commission on Ecosystem Management, one of six commissions in which the volunteer specialist networks are able to contribute to the Union's mission, is pursuing four core priorities that are relevant to the Challenge Programme: a) Application of the Ecosystem Approach; b) Promotion of ecosystem restoration where appropriate to recover ecosystem capacity; c) development of standard categories of ecosystem status; and d) development and communication of ecosystem management tools. Arid and semi-arid lands are a Commission priority designed to complement the Secretariat's Arid Lands Initiative. IUCN is the world's largest environmental knowledge network and has helped over 75 countries to prepare and implement national conservation and biodiversity strategies. IUCN is a multicultural, multilingual organization with 1000 staff located in 42 countries. Its headquarters are in Gland, Switzerland. For more information on IUCN or the Commission on Ecosystem Management visit http://iucn.org

The United Nations Information Technology Service (**UNITeS**) coordinated by The United Nations Volunteer programme (**UNV**) is a special initiative to stimulate and channel the contributions of volunteers to help bridge the digital divide. Volunteers under the UNITeS initiative work directly with people and institutions (in developing countries) to build their capacity on the applications of information and communications technologies (ICT) to human development. UNITeS does not implement projects outright. UNITeS works as a global "infomediary" for matching demands for ICT assistance with qualified and skilled ICT volunteers. It channels volunteers of any nationality to any developing country, and also enables 'online volunteers'. There is no other ICT volunteer initiative with this global reach. Find out more about UNITeS at www.unites.org

Appendix VII. References cited

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Appendix VIII. Acronyms and abbreviations

ACMAD	African Centre of Meteorological Applications for Development
ACNU	Agroforestry and Novel Crops Unit (ACNU) of the School of Tropical Biology at James Cook University (JCU) in Cairns, Australia
ACSAD	Arab Center for the Studies of Arid Zones and Dry Lands
AFESD	Arab Fund for Economic and Social Development
AGRHYMET	Centre régional de formation et d'application en agrométéorologie et hydrologie opérationnelle
AOAD	Arab Organization for Agricultural Development
ARI	Advanced Research Institute
ARO	Advanced Research Organization
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
CAAS	Chinese Academy of Agricultural Sciences
CAZRI	Central Arid Zone Research Institute
CAZS	Center for Arid Zone Studies, Bangor, Wales
CBD	Convention on Biological Diversity
CEH	Center for Ecology and Hydrology
CERAAS	Centre d'Etude Régional pour l'Amélioration de l'Adaptation à la Sécheresse
CCD	Convention to Combat Desertification
CGIAR	Consultative Group on International Agricultural Research
CILSS	Comité permanent inter-états de lutte contre la sécheresse dans le Sahel
CIHEAM	International Center for Advanced Mediterranean Agronomic Studies
CIRAD	Centre de coopération internationale en recherche agronomique pour le développement
CNRST	Conseil national de recherche en science et technologie
COP	Conference of Parties
CRIDA	Central Research Institute for Dryland Agriculture (India)
CRRA-INRA	Regional Dryland Center of National Agricultural Research Institute of Morocco
CST	Committee of Science and Technology of UNCCD
DDPA	Desertification, Drought, Poverty, and Agriculture Challenge Program
DEDC-PAC	Dryland Ecosystems and Desertification Control Programme Activity Centre

Desert*Net	The German Competence Network for Research to Combat Desertification
DFID	Department for International Development (UK)
DMP	Desert Margins Program
DRC	Desert Research Center (Egypt)
DRFN	Desert Research Foundation of Namibia
DRSS	Department of Research and Specialist Services
EARS	Environmental Analysis & Remote Sensing, The Netherlands
ESCWA	Economic and Social Commission for West Asia
FAO	Food and Agriculture Organization of the United Nations
GEF	Global Environment Facility
GFAR	Global Forum on Agricultural Research
GIS	Geographical Information Systems
GLASOD	Global Assessment of Soil Degradation
GM	Global Mechanism of the UNCCD
IAWGD	Interagency Working Group on Desertification
ICAR	Indian Council for Agricultural Research
ICARDA	International Centre for Agricultural Research in the Dry Areas
ICASALS	International Centre for Arid and Semi-Arid Land Studies
ICBA	International Center for Biosaline Agriculture
ICRAF	International Centre for Research in Agroforestry
ICRISAT	International Crops Research Institute for the Semi-Arid Tropics
ICT	Information and Communication Technology
IDDC	International Dryland Development Commission
IDRC	International Development Research Center
IE	Integrated Ecosystem approach
IER	Institut d'Economie Rurale
IFAD	International Fund for Agricultural Development
IFDC	International Fertilizer Development Centre
IFPRI	International Food Policy Research Institute
IIED	International Institute for Environment and Development
IITA	International Institute of Tropical Agriculture
ILRI	International Livestock Research Institute
INERA	Institut national d'études et de recherches agricoles
INRAN	Institut national de recherche agronomiques du Niger

INRM	Integrated Natural Resource Management
INSAH	Institut du Sahel
IPALAC	International Program for Arid Land Crops
IPGRI	International Plant Genetic Resources Institute
IRD	Institut pour le Developpement (France)
IRI	International Research Institute for Climate Prediction
iSC	Interim Science Council of the CGIAR
ISNAR	International Service for National Agricultural Research
ISRA	Institut senegalaise de recherche agricole
ISRIC	International Soil Reference and Information Centre
IUCN	IUCN – The World Conservation Union
IUSS	International Union of Soil Science
KARI	Kenya Agricultural Research Institute
KEFRI	Kenya Forestry Research Institute
LUCID	Land Use Change in Drylands Project
NEAP	National Environment Action Plans
NAP	National Action Programme of the UNCCD
NARS	National Agricultural Research System(s)
NARES	National Agricultural Research and Extension System(s)
NCC	National Coordination Committee
NGO	Non-Governmental Organization
NRM	Natural Resource Management
PACD	Plan of Action to Combat Desertification
QTL	Quantitative Trait Loci
RAP	Regional Action Program
RFI	Range Forage Institute
RRO	Regional Research Oranization
SADC	Southern Africa Development Community
SAT	Semi-Arid Tropics
SG2000	Sasakawa Global 2000
SPAAR	Special Program for African Agricultural Research
SRAP	Sub-Regional Action Programmes of the CCD
SRO	Sub-regional Research Organization
SSA	Sub-Saharan Africa
SWNM	Soil, Water and Nutrient Management Program
SWMNet	Soil, Water and Nutrient Management Network of ASARECA

SSWNMRI	Systemwide Soil, Water and Nutrient Management Research Initiative
STAP	Scientific and Technical Advisory Panel of the GEF
TAC	Technical Advisory Committee of the CGIAR
TIGR	The Institute for Genomic Research
TK	Technology and Knowledge
TPN	Thematic Programme Network of the UNCCD
TSBF	Tropical Soil Biology and Fertility
UK	United Kingdom
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
UNCED	United Nations Conference on Environment and Development
UNCOD	United Nations Conference on Desertification
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNITeS	United Nations Information Technology Service
USAID	United States Agency for International Development
UNSO	UNDP Office to Combat Desertification and Drought
WANA	West Asia North Africa
WCRP	World Climate Research Programme
WMO	World Meteorological Organization
WWF	World Wildlife Foundation